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Contents

	PAGE
Phosphoric High-Duty Cast Irons	85
Stirrup Pump Attachment	86
Creditors and Debtors	86
Notes from the Branches	86
Random Shots	86
Magnesium Foundry Practice	87
Principles and Practice Involved in the Production of Steel Castings	91
Electric Steel Furnaces	94
Two Methods of Moulding a Drum Casting ...	95
Vitreous Enamelling Section—	
The Acid Resistance of Finished Enamelware ...	96
The Week's News in Brief	100
Trade Talk	100
Personal	100
Obituary	100
Parliamentary	100
Raw Material Markets	102
Reports and Dividends	102

Phosphoric High-Duty Cast Irons

The Institution of Mechanical Engineers Research Committee on High-Duty Cast Irons for General Engineering Purposes has performed a notable public service at the present time in issuing a Report on phosphoric high-duty cast irons. Two Reports have in fact been issued, the second relating to what are conveniently termed special-duty cast irons, the austenitic and martensitic irons, but to this we hope to return later. The circumstances of the time are such that the fullest possible use must be made of home resources in iron ore, and the most readily accessible and easily treated of these are phosphoric. Now, phosphoric irons are very widely used in this country, particularly for light castings, for which, as the Report points out, they are peculiarly well suited, but when the product is to be submitted to engineering tests prescribed in a multitude of specifications, a new situation arises and it must not be supposed that the regular mode of production in a light-castings foundry is adequate, because the major problems in the use of phosphoric irons do not arise in thin sections. The object of the Report is to show what precautions should be taken with respect to composition and other matters to enable the highest possible percentage of phosphorus to be used without incurring serious drawbacks. Now the use of phosphorus in engineering castings is well established in this country but it is only in recent years that investigation has shown why practice adopted in these cases is successful and hence only now that the more general use of phosphoric irons can be envisaged with any prospect of success. Singularly enough, while this has been going on, there has been a pronounced tendency towards the use of low phosphorus material in engineering castings, for which various reasons are advanced in the Report. This is followed by a consideration of the effect of phosphorus on structure and the carbon, silicon and phosphorus contents are given for both reasonable strength and soundness, from which it is clear that, necessary as low-phosphorus contents are in small castings having inevitably high carbon and silicon contents, it is not at all necessary either for strength or soundness that larger castings should have low phosphorus contents since they carry lower carbon and silicon contents. Furthermore, the founding difficulties diminish and the resistance to wear arising from a higher phosphorus content may be a considerable asset.

The Report is prepared mainly for users, but it indicates without too much technical detail that for ordinary plain cast irons such as still constitute the bulk of the output, phosphorus is beneficial in its effect on strength, tensile and transverse, and on deflection, up to about one-third of one per cent. These properties rise until that figure is reached, and then approach a peak, because after that, as phosphorus increases further, these properties fall, returning to their phosphorus-free values at about two-thirds of one per cent. At still higher values, these properties continue to fall. Some idea is given of the magnitude of these changes, although any metallurgist knowing the range of values from any one composition would not expect to be given specific figures. The increase in hardness due to phosphorus is shown by the fact that Brinell values increase regularly with phosphorus, the hematite iron being softest, but it does not follow that phosphorus militates against machinability. Conversely, as phosphorus increases the shock strength goes down, the hematite being the toughest of the series. Again, the magnitudes of these changes are indicated and the effect of annealing is given. The value of phosphorus in wear resistance is stressed, and the effect of phosphorus on mechanical properties at elevated temperatures is covered.

The kernel of the Report is contained in three ingenious diagrams, which, if used with the precautions stated, should be of great value. Each diagram refers to a specified range of carbon content, and for that range shows for any given silicon and phosphorus content what grade of iron will be met, the B.S.I. grades being used. Thus if a foundry finds that it is making metal to a certain composition and is not reaching the indicated grades of strength, the founder knows what can be done and can obtain advice as to how to reach them. The figures are on the conservative side, so that those from the best foundries should be rather better than the diagrams indicate, while further improvement can be had by alloy additions and special processing, on which irons a further report is promised.

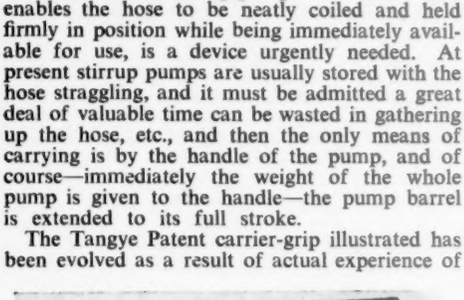
Altogether the Committee is to be congratulated on a very useful and practical Report, the brevity and freedom from technicalities of which should commend it to all engineering users and notably assist the war effort. Foundries finding themselves unable to reach the levels shown should be given time to adapt their practice accordingly. Conversely, founders who can and do, should be able to undertake national work with confidence, both on their own part and on the part of contracting departments placing orders.

Stirrup Pump Attachment

HOSE GRIP AND CARRIER

A convenient stirrup-pump attachment that enables the hose to be neatly coiled and held firmly in position while being immediately available for use, is a device urgently needed. At present stirrup pumps are usually stored with the hose straggling, and it must be admitted a great deal of valuable time can be wasted in gathering up the hose, etc., and then the only means of carrying is by the handle of the pump, and of course—immediately the weight of the whole pump is given to the handle—the pump barrel is extended to its full stroke.

The Tangye Patent carrier-grip illustrated has been evolved as a result of actual experience of



STIRRUP PUMP CARRIER AND HOSE GRIP.

these serious inconveniences, and the carrier-grip definitely solves the problem, and now converts the stirrup pump from an armful to a one-hand job.

The outstanding advantages of the attachment are: (1) It keeps the hose in instant readiness—no kinks, no twists, no delay; (2) the nozzle is kept clean; (3) it provides convenient carrying handle for whole pump; (4) only the required length of hose need be drawn off the clip; (5) it provides a hook for hanging on wall, nail or ledge; and (6) it can be fitted in a few minutes.

The attachment is manufactured and supplied by Tangyes, Limited, Cornwall Works, Birmingham.

Creditors and Debtors

THE COURTS (EMERGENCY POWERS) ACT 1941

The 1941 Act which amends the Courts (Emergency Powers) Act, 1939 (the principal Act), and the 1940 Act, contains provisions of importance which can only be simply explained by reference to the Principal Act. The thesis of that Act was that notwithstanding that a court judgment had been obtained as regards debts, etc., before the judgment or order can be enforced "leave of the court" to proceed must be obtained, as the circumstances of the war may have altered the position between the creditor and debtor. Furthermore, whereas formerly certain remedies were open to the ordinary individual without court action, with reference to such things as the levying of distress, taking possession of property, realisation of a security, and so forth, leave of the court must be obtained before the remedy can be set in motion.

These Acts provided that this procedure should only apply to matters which had happened before the war (*i.e.*, September 2, 1939); this 1941 Act now provides that this "leave of the court" procedure shall apply to post-September 2, 1939, matters, the same as to pre-September 2, 1939, matters, providing it is shown that the person unable to meet his obligations has been "hit" by war circumstances, which have arisen since the obligation was entered into. As regards the "remedies" (*e.g.*, levying of distress, etc.) mentioned earlier, the procedure is the same as under the 1939 Act, that is, the onus is still on the creditor, etc., to take court action.

The position is different as regards court judgments and actions, in relation to post-September 2, 1939, matters. In these cases (*e.g.*, ordinary debts, taking possession by a mortgagee or landlord in default of payment of money or rent, delivery up of other goods, etc.), for execution or enforcement to be postponed, the defendant and not the plaintiff is required to go to the relevant court (*e.g.*, County Court or High Court) and prove the "hit by the war" rule, as above, meaning that he has been adversely affected by war circumstances, which have arisen since the contract, lease, mortgage or tenancy was made or entered into.

Notes from the Branches

East Anglian Section.—On July 19, due to the kindness of the directors of Ransomes & Rapier, Limited, about 30 members of the East Anglian Section of the Institute of British Foundrymen made a tour of these works. They were welcomed on arrival by the works manager, Mr. N. F. Dare. There was so much of interest to the visitors that the time available seemed all too little. A giant mechanical excavator was seen in process of assembly as well as mobile cranes of various sizes. Models of some types of sluice and dams, made by the firm, built on a miniature river and actuated with water controlled by a pump, claimed much attention.

The value of the visit was greatly increased by the efforts of the guides, Mr. R. Coates, Mr. A. Horton, Mr. C. Jennings, Mr. J. King, and Mr. A. Sumner, who supplied the answers to many questions, particularly as each party came to inspect the foundry. The manufacture of castings in this department had formed the subject of a Paper presented by Mr. J. King to the Section earlier in the session. At the termination of the visit, members assembled in the works' canteen, where tea was served.

The Section President, Mr. Geo. Hall, thanked the directors, Mr. Dare, and all who had helped in making the visit so pleasurable. He was supported in this by Mr. H. H. Shepherd (Past-President). Both Mr. Dare and Mr. King made suitable responses.

Publication Received

Steel Horizons, Vol. 3, No. 2. Published by the Allegheny Ludlum Steel Corporation, Pittsburgh, Pa.

This remarkable house organ is quite different from anything issued by any metallurgical enterprise anywhere in the world. In the first place there is little about Allegheny Ludlum Steel Corporation beyond a couple of full-page advertisements. Then, the illustrations, making full use of colour, backed by the best in photographic art, are of such merit that few houses in Europe could equal them. Quite often, very well illustrated papers are content to let the pictures tell the story and the text is of pretty poor quality. Not so in "Steel Horizons," for the main article, by Dr. William A. Hamor, Assistant Director of the Mellon Institute, is a review of the whole field of recent industrial research, which is as interesting as it is authoritative. Other articles cover such diverse subjects as the testing of insecticides; the rayon industry; the R.C.A. electron microscope; the descriptions of chemical and textile factories. In connection with the last two it is mentioned that they use stainless steel, so that one can presume that here is the connection between the firm's products and its house organ!

Random Shots

A well-known foundry metallurgist found himself in the position of having to explain to a completely lay audience something about moulding. To most of us, the idea of a pattern and mould or mould and casting being positive and negative is so common that we find it difficult to understand that it cannot already be familiar to the uninitiated, although so it is. The average person, even if he can grasp the idea of a mould from childish experiences on the sands, must find it rather difficult to conceive how you could possibly make a casting of a hollow object. When the nature of a core is explained, the invariable question is how are the mould and core kept separated by just that amount that is to be the thickness of the metal. As a matter of fact, our friend explained it by saying that golf, in a normal right-handed person, is a game to be played with the left hand, while for a left-handed person it is a game to be played with the right hand. Moulding, he continued, was in a way parallel with it. A mould was a box of sand, the contours of which corresponded with the external shape of the article to be cast, while the core within had an external contour corresponding with the the internal shape of the article to be cast. There is no doubt that both golf and founding at times fray the temper, but they differ in the sense that one is given up for the sake of the caddies, but the other has to be endured for the sake of the kiddies.

* * *

Moulding, coremaking and patternmaking are very different and yet complementary crafts, and the exponent of each is apt to consider that he has to bear the major part of the responsibility and to get most of the kicks when there is a failure. But, unlike faith, hope and charity, it is difficult if not impossible to say which is the greatest of these. All of which may explain why, when there is an argument to locate responsibility for a failure, the three regard each other with a mixture of patronising, condescension, and latent hostility that may grace the personal relations of, say, bomber and fighter pilots.

* * *

A correspondent from the United States draws attention to the difficulty some writers have in making up their minds whether or not cast iron should be spelt with a hyphen, and curious mixtures are the result. But the solution is really very simple. When used as a noun, there is no hyphen. When used as an adjective, as in such phrases as "cast-iron baths," the hyphen should be used. Such phrases in common speech as "cast-iron alibi," or "cast-iron certainty," undoubtedly date from the time when, as the first ferrous structural engineering material, cast iron demonstrated its strength and rigidity over earlier materials, such as timber. They are certainly used, and mostly used, by people who would be completely non-plussed if asked exactly what cast iron really was. The rise of cast iron was, however, sufficiently in advance of that of steel to enable the engineers of the time to leave a few monuments to their skill, such as Southwark Bridge, Paddington Station arches, and the Crystal Palace.

* * *

These columns have often been opened to discussions on the largest casting ever made, but what is the smallest? How many of it go to the pound weight? And what, for its size, is the most intricate?

* * *

London Housewife: "What are they queueing up here for?"

Woman in queue: "Shephard's Pie."

London Housewife: "Right, I'll join you. A bit of pie'll come in handy for the old man's supper."

"MARKSMAN."

Magnesium Foundry Practice*

By M. E. BROOKS and A. W. WINSTON

Introduced on a practical scale in 1929, the production of magnesium alloy sand castings increased tenfold during the following decade to reach more than a million pounds in 1939, according to U.S. official statistics. It is estimated that U.S. production in 1940 rose to about four million pounds and will more than double again during the current year. At least a score of foundries are casting magnesium, providing convenient availability in all major industrial areas throughout the States.

The outstanding characteristic of magnesium castings is, of course, their lightness. Cast iron is four times, brass five times, and even aluminium is 50 per cent. heavier than magnesium. This light weight, combined with adequate mechanical properties, has led to the use of magnesium castings in a wide variety of applications in which reduction of weight is needed. These include portable tools, textile and packaging machinery, transportation equipment, and large ventilating fans. The largest castings regularly made are 1,000-lb. bases and housings for pumps to be mounted on trucks. Of great national interest at this time, are the many applications in the aircraft industry, the largest consumer of magnesium castings. Here they are indispensable for engine parts, landing wheels, aeroplane structural fittings, and many accessory and instrument parts.

The sand foundry practice for magnesium alloys is similar in general principles to that used for other metals. However, there are numerous points of difference, necessitated by the ease of oxidation of magnesium at temperatures above the melting point of approximately 605 deg. C., a rather high shrinkage (⅞ in. per ft. when unrestrained), and by the low density of the molten metal, which is slightly more than 1.5 at 700 deg. C. The first of these characteristics requires that oxidation inhibiting agents be present in the sand and that special fluxes be used in the melting operation. Special methods of gating, venting and risering castings have been developed to offset the problems due to the high shrinkage and to the light weight of the molten metal. The procedures described in this Paper may be considered to present American practice fairly completely. However, no attempt is made to cover all the operating "kinks" in use in individual foundries, nor to make comparisons with European practice.

Moulding Sands

Magnesium sand castings are made in "green" sand moulds, or, less commonly, in "dry" or baked sand moulds. The latter are similar to baked sand cores in composition and treatment. Magnesium castings are moulded in both natural and synthetic sands. It is desirable that the sand should be as open as possible, consistent with obtaining the degree of surface smoothness required. The more open sand is desirable for two reasons:—(1) Magnesium alloys are so light that an open sand permits the metal to flow into the mould cavities with very little back pressure from the air in the mould; and (2) the open sand requires less tempering water and evolves less steam, and also it permits the steam generated to escape quickly, thus decreasing the tendency for reaction between the steam and metal.

Natural sands, of the Albany and Champion types, are used in several foundries. The average grain fineness is from 100 to 150, with an A.F.A. permeability ranging from 10 to 25. They contain 10 to 12 per cent. clay and require about 6 per cent. water for tempering. Foundries operating with natural sand generally use the heap method and recondition their sand with equipment of the aerator type, with only occasional mulling, if any. The high water content of the natural sands results in considerable steam formation as the mould is filled.

This fact, combined with poor venting due to low permeability, necessitates the use of rather high quantities of inhibitive agent to prevent surface oxidation or "burning." As much as 10 per cent. agent may be added, and this amount may not be adequate on heavy sections. More open sands should be used if any sections more than 2 in. thick are regularly encountered. Misruns, cold shuts, and other casting defects also may be caused by too slow venting of the mould air during the filling of the mould. Subject to the limitations just described, natural sands may be used for the production of light to medium-sized castings.

Synthetic Sands

Synthetic moulding sand is being used to an increasing extent in magnesium foundries; in fact, it will be used in all of the several larger foundries recently started or being built at this time. The synthetic sands preferably are made from a washed silica base with an A.F.A. grain fineness of 65 to 100, mulled with 3 to 4 per cent. bentonite and about the same amount of water. Bank (dune or river) sands also may be used if free from roots, coal, or other organic matter which might cause blows.

The sand is conditioned after each use; tempering, mulling, and aerating being done in standard equipment. Care should be taken to remove wood and paper particles, as they absorb moisture from the sand and cause blows if contacted by hot metal. Contamination with iron scale or rusty iron particles, such as steel wire and shot, should be avoided, as these will also cause blows.

Considerable latitude exists in synthetic sands and the A.F.A. properties shown in the accompanying Table I may be considered to be typical of satisfactory sands of various grain sizes.

TABLE I.—*Moulding Sand Mixtures for Magnesium Castings.*

	A.	*B.*	*C.*
Average grain size..	100	80	65
Permeability ..	35 to 50	60 to 75	120 to 150
Bentonite, per cent.	4	4	4
Water, per cent. ..	4.5 to 5.0	3.8 to 4.2	3.3 to 3.7
Compression strength, lbs. per sq. in.	6.5	6.5	6.5

The strength will be affected slightly by the kind and amount of addition agent in the sand and greatly by mulling, which should be done thoroughly between each use. The finer sand *A* of Table I will give the best casting surface but will possess, to some degree, the disadvantages of fine natural sand as discussed earlier. Very often sands, such as given under *C*, Table I, while entirely adequate from the permeability standpoint, tend to dry out easily and to give rough surfaces on the castings. The former tendency is overcome in American practice by the use of approximately 1 per cent. ethylene glycol in the sand. Smoking of the mould surface is practised in foundries using such open sands, and may be of value in improving the casting surface.

In the opinion of the authors, an intermediate sand such as given under *B*, Table I, is preferable for general use. It yields a fairly good casting surface and has proved satisfactory for castings weighing up to 1,000 lbs. and for sections up to 8-in. thick. It is easier to work than coarser sands, and will stand for considerable variation in ramming conditions.

Excessive bentonite causes the sand to become sticky and difficult to work. Additions to the sand will be required occasionally. To avoid lumps in infrequently mulled heaps, the bentonite may be suspended in the tempering water.

Sand Agents

It is necessary that all green moulding sand be treated with a chemical agent to inhibit the action of the water vapour upon the hot metal. The first inhibitors were developed by German foundrymen, who discovered that sulphur and boric acid would protect magnesium-base alloys cast in green sand. Later research in this country has shown that there are a large number of chemicals which will serve as inhibitors. Of these, various fluoride salts are particularly effective. American foundries at present are using combinations of several agents. One is a mixture of sulphuric acid, borax, and sulphur, practically equivalent to boric acid and sulphur in protective value. Better protection, especially necessary with low permeability sands, is obtained by replacing part of the sulphur and boric acid with fluoride salts. Originally ammonium acid fluoride and ammonium borofluoride were used for this purpose, but they have been replaced largely by the cheaper ammonium silicofluoride.

In general, the total amount of inhibiting agent will range from 4 to 10 per cent. by weight, depending on the sand used and the section thickness of the castings produced. The larger amounts will be required for lower permeability sands and for massive castings. The concentration of agent slowly decreases as the sand is used, and more must be added to maintain the proper degree of protection. A convenient control method is to hold the total water-soluble salts, as indicated by a simple analysis, within set limits by the addition of ammonium silicofluoride and boric acid. Powdered sulphur additions are made as indicated necessary by a determination of the CS_2-soluble content of the sand.

Coremaking

Cores for magnesium castings should be made from an open sharp sand, and should be provided with adequate vents to facilitate removal of hot gases. Most core troubles can be traced to lack of attention to details ensuring a minimum of gas evolution or to failure to provide venting of the gas which is formed.

Binders

Generally, any good quality core oil is suitable for use, but preference should be given to those forming a minimum of gas. Cereal binders find a limited application. As they tend to absorb moisture, special care is necessary to keep cereal-bonded cores warm and dry before use. In choosing a core binder, consideration must be given also to the ease with which the cores can be removed from the casting as determined by trial. Ordinary ratings of this characteristic may not apply in casting magnesium alloys, as the temperature and heat capacity of the light metal surrounding the core is low and the core bond will not be burned out as in the casting of heavier metals.

Use of Inhibitor

It is necessary that the core sand be treated with an inhibitor to prevent burning of heavy metal sections. Two types of practice have been developed for obtaining this protection: in one case, low percentages of sulphur and boric acid are mixed with the core sand, while in the other type, the baked cores are sprayed with an aqueous solution of a fluoride. In the latter

*A Paper presented to the New York Convention of the American Foundrymen's Association. The authors are on the staff of the Dowmetal Foundry, The Dow Chemical Company, Bay City, Mich.

Magnesium Foundry Practice

case, it is necessary to return the sprayed cores to the oven for a short drying period (30 to 60 mins.) after the spraying operation. The fluoride spray is used also on the cores containing sulphur and boric acid where very heavy metal sections contact the core. Additional protection is sometimes obtained by painting parts of cores with a suspension of sulphur in alcohol. This is used to a limited extent, however, due to the danger of too heavy a coating of sulphur remaining on the core and causing trouble by bubbles of gas passing through the metal.

Core Mixtures

A typical core sand mixture for general use is as follows:—

	Parts by volume
Sand*	1,000
Oil	12
Dextrine	8
Sulphur	13
Boric acid	13

Standard A.F.A. specimens, before and after baking for two hours at 215 deg. C., will have approximately the following properties:—

Green compressive strength, lbs. per sq. in.	0.3
Baked tensile strength, lbs. per sq. in.	120
Hardness	85
Permeability	85

FIG. 1.—MAGNESIUM CASTING SHOWING GATING AND RISERING.

By the addition of more oil, the strength can be raised as desired, but care should be taken to avoid excessively strong internal cores, as they may cause casting cracks. Softer cores may be made by reducing the amount of oil, with, of course, increased fragility and difficulty in handling. The addition of 5 parts (volume) of bentonite raises the green compressive strength to about 1.0 lb. per sq. in., and may be desirable for certain jobs. However, additional oil will be required to maintain the desired baked strength.

Baking Temperatures

Cores for magnesium castings should have a minimum of oil and should be baked thoroughly. The temperature of baking will be dependent on the oil, but generally will be between 205 deg. C. and 230 deg. C. Shell carriers are used extensively, due to the high dimensional accuracy required in aircraft castings.

Pasting Practice

The cores are necessarily soft, and to facilitate pasting, the joining surfaces are painted with a 1 to 3 shellac-alcohol solution to give a stronger surface. Care is taken that the paste does not come through to the surface of the core with resultant danger of a blow. Joint lines and shallow surface defects may be smoothed with the following mixture, made up to a soft paste with denatured alcohol containing a little lubricating oil for bond:—

	Parts.
Talc	25
Sand (200 mesh)	75
Sulphur	2
Boric acid	2

The area is thoroughly dried by torch or by returning the core to the oven.

Chills

Chills are placed in the cores where necessary and may be either of the round button type or formed to fit the contour of the casting surface. Cast iron generally is used, as it is cheap and does not alloy with molten magnesium. The greatest objection to copper-base chills is the contamination of melts from chills adhering to scrap castings. Some operators prefer to score the face of the chill to avoid blows, but this does not appear to be necessary if precautions are taken to prevent condensation of moisture on the chill. This is best accomplished by the use of some type of a coating, which must be thin and contain no material which will give off gas upon contact with the hot metal. A suspension of talc in alcohol containing 1 oz. per gall. of either "Mazein" or resin makes a satisfactory coating material. It is necessary that the chill be clean and free from any rust or moisture.

Storage

Cores which do not go directly from the baking racks and assembly benches to the moulding floor are stored in a room which is maintained at a temperature of at least 38 deg. C. This ensures that the cores will be thoroughly dry when placed in a mould and eliminates the foundry troubles incident to damp cores.

Moulding Practice

The moulding of magnesium alloy castings is probably the most important single phase of the entire foundry procedure. While it is desirable in the founding of all metals that the mould should be so constructed that the metal will flow into the mould cavity smoothly and with a minimum of turbulence, it is essential with magnesium alloys, and deviation from this basic foundry rule will result in scrap castings. Excessive turbulence in the metal stream, from the time it leaves the melting unit until the metal has reached its final place in the casting, will cause oxide skins to become mixed with the metal. These oxide skins, being of about the same specific gravity as the metal, do not separate from the metal, but are swept into the casting, where they tend to rise to the cope side and appear after blast cleaning as surface defects. In addition to the surface defects caused by the oxide skins, a further result of turbulence in the metal stream is the entrapping of bubbles of air, which also tend to rise to the cope surface and are opened during cleaning operations and appear as blows or gas holes.

Filters for Oxide Films

To avoid turbulence in the mould, the casting should be gated in such a way that the metal will be brought into the mould cavity at the lowest point and the gates so arranged that the sprue can be filled as quickly as possible after pouring starts. Filters placed at the bottom of the sprue are very effective aids in keeping out oxide skins and smoothing out the metal flow. Two types of filters used are:—(1) Perforated skim gate; and (2) steel wool. To be effective, either of these materials should be placed at the bottom of the sprue or in the horizontal runners in such a way that the metal must flow through them on its way into the mould cavity.

Pouring Basins

Of vital importance in the proper filling of the mould is the use of a correctly-designed pouring basin. This may vary in size from small cast-iron ones used on bench moulds to large ones made of green sand for large floor moulds. The basin must always be long enough and deep enough to allow the metal stream to enter without direct impingement on the sprue and to permit the metal to quieten down before entering the sprue.

Sprues

Two types of sprues are used, round and rectangular slots. The round sprue is moulded more easily and is commonly used in conjunction with the perforated skim gate. The rectangular slot sprue is claimed to decrease turbulence because of the prevention of any swirling tendency of the metal. It is used either without any filter material or with steel wool. In any case, the sprue must be of such a size that it can be choked easily so that all the opening from the bottom gate up into the pouring basin can be filled quickly to prevent oxide skins being washed down the sprue and into the casting.

Gating

The casting should be filled through a number of gates rather than a few large ones. This is desirable to avoid overheating of the sand at the gates and because molten magnesium loses its heat so very rapidly that any attempt to flow metal any great distance through a thin casting section will result in misruns. A common type of gating is to place a ring runner completely around the casting with a number of gates entering the casting uniformly around its circumference. Adequate vents should be provided from the tops of runners to prevent building up pressure in the mould passages. This is especially important in moulds which are poured rapidly at high temperatures.

FIG. 2.—MAGNESIUM CASTING SHOWING GATING AND RISERING.

Risers

Risers are used freely to ensure the soundness of heavy sections of castings. Because of the light weight and low heat content of the metal, it is necessary that the riser be connected as directly as possible to the section to be fed. It sometimes is found to be good practice to place a riser over a gate to hold up shrinkage in a section which is difficult to feed by direct risers.

Compared to the practice with many other metals, the risers required for magnesium alloys are much larger and greater in number. The castings, shown in Figs. 1 and 2, are fairly typical of the procedure followed on magnesium castings.

Chills

Chills frequently are used to equalise the freezing of heavy and light sections. After each use, the chills are thoroughly heated in a core oven to 205 to 220 deg. C. They are then

*The sand is a mixture of 40 per cent., with 100 average grain fineness, and 60 per cent. with 65 average grain fineness. The moisture content is 6.5 per cent. by weight.

Magnesium Foundry Practice

blast cleaned and sprayed while hot with the chill coating solution described under the section in which cores are discussed. They are kept in a warm place until ready for use, but are allowed to cool to room temperature just before placing in the mould, which is closed and poured as soon as possible.

Melting Practice

Magnesium alloys for sand castings are melted by two methods, the open flux pot and the crucible. The former method uses a relatively large amount of fluid chloride-base flux (10 to 20 per cent. of the metal weight) at the bottom of a large, cast steel, stationary pot. The flux serves the dual purpose of cleansing the metal and protecting it from oxidation. The metal is hand dipped in ladles holding up to 25 lbs. The present use of this method of melting is limited to the production of small castings and to cleaning and reclaiming scrap. It has been described in detail by Gann and Brooks. The crucible method, using individual melts, is used much more generally, as it is more adaptable to pouring large castings and to usual foundry production methods.

Crucibles and Furnaces

The crucibles ordinarily are made of low carbon steel. A "fire-box" grade of steel may be desirable for the larger sizes. The crucibles are used without lining, as iron is almost insoluble in molten magnesium, even at 870 deg. C. The crucibles in current use range from 60- to 600-lb. capacity, and are heated in oil- or gas-fired furnaces. Up to a total weight of about 200 lbs. (120 lbs. of magnesium alloy) the crucibles are carried to the moulds manually or on small rubber-tyred bogies. Above this weight, monorail conveyors and cranes are used to transport the metal.

Crucible Inspection

It is desirable that the furnace design and the combustion control be such as to minimise the scaling on the outside of the crucibles. Crucible settings are cleaned daily to ensure that no accumulation of oxide occurs. If molten magnesium from a leaking crucible comes in contact with hot iron scale, a violent reaction of the thermit type may result. The crucibles are examined frequently, at least every eight hours, and are discarded if thin spots are indicated by hammering. Scaling is the usual cause of crucible failure, and in the interest of economy and safety, consideration is, or should be, given in every foundry to methods of controlling it.

Types of Crucibles

Non-scaling stainless steels containing considerable nickel cannot be used for crucible construction, because of the resulting contamination of the melt with nickel. High chrome iron (28 per cent. chromium) has been used to some extent, and is satisfactory from the scaling standpoint. In the absence of scaling, mechanical distortion and weld cracking, due to prolonged exposure to high temperatures, govern the useful life of the crucible. At the moment, the cost of the high-chrome iron crucibles does not appear to be justified. Data are not available on the performance of chrome irons with lesser amounts of chromium or on carbon steels clad with non-scaling material on the exterior.

While not a factor with ordinary steel crucibles, there is some indication that pitting or corrosion on the interior by melting fluxes may affect the performance of long-life crucibles. Silicon carbide crucibles can be used, but are not handled as conveniently as the steel crucibles. However, they are necessary if it is desired to cast magnesium alloys with less than 0.020 per cent. iron contamination. Clay or clay-bonded refractory crucibles should not be used because of attack by the molten metal and fluxes.

At present, the most practical solution of the scaling problem appears to be the use of low carbon steel crucibles with the outer surface calorised or aluminium-sprayed, sealed and annealed by the Metcoseal process or its equivalent. Satisfactory results also have been obtained by dipping freshly cleaned steel crucibles in molten aluminium for 20 mins. at 815 deg. C. Crucibles coated with aluminium by any of these processes do not scale, but are discarded after 250 to 300 heats because of distortion, and thus give three to four times the life of ordinary steel crucibles.

Crucible Melting

In the crucible method of melting, protection of the magnesium alloy from oxidation is by the use of a special flux (Dow Flux No. 31) which is fluid when first melted but which becomes dry and crusty after brief exposure to high temperatures. In melting down, the usual procedure is as follows: A light sprinkle of flux is placed in the crucible, which then is charged with ingot and scrap metal. As the metal is charged and during the melting process, flux is dusted on the surface in such quantities as are needed to prevent burning. The amount of flux required during this operation is small, but it is essential that the molten metal, as it wells up in the crucible, should be kept dusted with a light layer of flux. If this be not done, considerable burning will take place with resultant loss of metal and fouling of the melt and crucible walls with oxide.

Fluxing

After the metal is melted, and at a temperature not exceeding 705 deg. C., the melt is stirred. This operation is performed with a 1-in. iron rod bent in the form of an "ell" with the short leg approximately the depth of the crucible. This stirring rod is moved in the crucible in such a manner as to give a rotational motion to the melt. During the stirring operation, flux is added in sufficient quantity to form a fairly heavy coating on top of the melt. The stirring causes the flux to wet the oxide particles in and on the melt, thereby making them heavier and causing them to separate and sink to the bottom of the crucible. If the stirring and fluxing have been properly done, the metal surface will have a clear silvery lustre. If it appears dull or frothy, the dross and flux should be removed from the surface of the melt with a skimmer and the stirring repeated with fresh flux.

Heating and Pouring

After the stirring is completed, the thermocouple is inserted and the surface of the melt is covered carefully with flux, particular attention being given to the area where the surface of the melt contacts the crucible wall and around the thermocouple. It is necessary that the melt be well covered with flux at this stage to prevent burning during the subsequent heating period. The crucible contents are then heated to approximately 870 to 895 deg. C. and allowed to cool to the casting temperature, which generally is between 760 and 870 deg. C. The superheating operation refines the grain and thereby improves the mechanical properties of the alloy. It is very important that flux should not be used on the metal too short a time before casting. If the flux has not had time to thicken and dry, it may flow out with the metal and cause detrimental inclusions in the casting.

After the crucible is ready for casting the surface of the melt is cleaned by carefully spudding away and removing the scale of flux and oxide from the pouring lips and the surface of the melt. The metal burns readily at this temperature (760 to 870 deg. C.) as soon as the protecting flux is removed. Burning during the cleaning of the melt and the pouring of the casting is controlled by dusting on the surface of the metal a powder containing 80 per cent. sulphur, 17.5 per cent. boric acid, and 2.5 per cent. ammonium borofluoride.

It is standard practice in some foundries to add 0.05 per cent. metallic calcium to the crucible just before the metal is poured. Calcium helps prevent surface oxidation of the casting in the mould if the agents in the sand do not adequately protect the metal. The calcium also may afford some protection during heat treatment. The amount added is controlled carefully because more than a few hundredths of a per cent. slow up the rate of solution heat-treatment.

Cleaning the Crucible

After the casting has been poured, the crucible is returned to the melting floor and cleaned preparatory to charging for the next melt. If proper casting practice has been followed, a layer of molten metal about 2 or 3-in. deep has been left in the bottom of the crucible. This residual metal is desirable for two reasons: (1) The danger of pouring flux with the metal is much less if the crucible is not drained, and (2) the presence of molten metal facilitates melting down the next charge. The side walls of the crucible are spudded down and the dross removed from the surface of the melt and the bottom of the crucible by means of suitable tools. During this cleaning operation, sufficient flux is sprinkled on the metal to prevent burning. The crucible is now ready to charge for the next cycle of operations.

Charges

The normal consumption of flux in the crucible melting method is between 2 and 3 per cent. of the weight of the metal melted. The crucible charge may consist of either 100 per cent. virgin ingot, 100 per cent. scrap, or a mixture of both. If the melting operation is properly carried out, the properties of the resulting castings will be independent of the nature of the charge. The usual foundry practice is to use about 40 per cent. ingot and 60 per cent. scrap for each melt. Scrap for use in the crucible should be clean and free from metal screens and adhering sand. The latter might result in increased silicon content, as sand is reduced by molten magnesium.

Temperature Control

Accurate melting and pouring temperature control is necessary, and this is secured by the use of either chromel-alumel or iron-constantan thermocouples in mild steel protection tubes immersed in the melt. The crucible is cooled in the furnace or is removed from the furnace above the desired pouring temperature and allowed to cool in the pouring shank until ready.

Large Scale Melting Units

During the past year, the increases in magnesium foundry production have stimulated the development of large melting units of 1,000 to 2,000-lb. capacity, from which metal is poured into small individual crucibles at about 705 deg. C. The small crucibles then are placed in their furnaces, fluxed and brought up to temperature as described earlier. Ingots and scrap are melted together, the large size of the batch permitting improved composition control. Production from the small crucibles also is speeded up as they are charged with metal already melted. These large units are oil or gas-fired and are of both centre-tilting and nose-tilting types. The melting pots are of heavy wrought steel construction similar to the small crucibles. Protection from oxidation is secured by the use of flux. Additional developments can be expected as experience is gained in the operation of these units.

Removing Gates and Risers

After cooling for a safe period following the pouring, the castings are shaken out by hand or on vibratory screens. The cores are removed

Magnesium Foundry Practice

by vibrating and with hand and compressed-air tools. After blast cleaning, the gates and risers are cut off with metal-cutting band saws having four teeth per inch and running at 8,000 ft. per min. The sawdust is swept up frequently to minimise the possibility of ignition by occasional sparks from the saw. The gates and risers from very heavy castings may require removal by air chisels. Lathes and other machine tools also are used to remove gates and risers not easily accessible for sawing.

Heat-Treatment

If heat-treatment is desired, this usually is done before the final cleaning operations. The castings are brought up to the solution heat-treating temperature in not less than two hours, left for the specified total time, removed and cooled in air. The temperatures and total times for the two common magnesium sand-casting alloys are as follow:—H, 12 hrs. at 385 deg. C.; C, 20 hrs. at 405 deg. C. Slightly higher temperatures may be required if calcium has been used in the casting operation.

The solution heat-treatment increases the tensile strength and elongation, and is particularly desirable for parts requiring shock resistance, such as aeroplane landing wheels. If increased hardness and high yield strength are required, even at a sacrifice of elongation, these may be secured by an ageing treatment of 16 hrs. at 175 deg. C., following the solution treatment. Aircraft engine parts frequently are used in the heat-treated and aged condition.

Heat-Treating Furnaces

Circulating atmosphere, electric or gas-fuel furnaces are used for the heat-treatment of magnesium castings. Direct gas-firing is not recommended for temperatures above 390 deg. C. Indirect gas-firing should be as satisfactory as electric heat from the standpoint of atmosphere control, but might be less simple mechanically. For temperatures up to 425 deg. C., SO_2 has proved to be a satisfactory inhibitor of surface oxidation at a concentration of approximately 0.5 per cent. From preliminary tests, the use of an atmosphere made by the controlled combustion of natural gas followed by dehydration appears to be a possibility.

Cleaning

The cleaning room operations consist of grinding, filing and buffing. The remainder of the gates and risers are ground off smooth with the casting surface and as much of the general cleaning operation is done on the grinding wheels as is possible. Surplus metal, fins, etc., which are inaccessible to the grinding wheels are removed with rotary filing tools. These rotary files are mounted on flexible shafts and rotate at speeds up to 3,500 r.p.m., the smaller diameter tools running at the higher speeds.

In some castings, it is required that the entire surface be finished by grinding and polishing. This is usually done on buffing wheels to the surface of which has been glued abrasive powder of different grades. The grinding and polishing is done on machines which are equipped with dust-collecting systems, preferably individual, so arranged that the magnesium dust is wetted immediately with a heavy water-spray and is stored under a large excess of water. Final disposition of the sludge should be by burying after dilution with earth or old core sand.

Castings frequently are pressure tested with air or water to determine their tightness for certain applications. While improved gating and risering methods will go far in securing tight castings, occasional recourse to impregnation is necessitated by the design of particular castings. A satisfactory impregnation method includes vacuum-pressure treatment with tung oil. The oil is later polymerised to an insoluble solid within the microscopic pores of the casting by heating the casting to 245 to 260 deg. C. for a short time. Some alloys are less subject to intercrystalline shrinkage than others, and, therefore, make it easier to produce pressure-tight castings. For this reason, preference is sometimes given to the composition represented by C in Table II, especially for engine castings.

Pickling Treatment

After the castings have been completely cleaned, they are again blastcleaned to give a uniform surface appearance. They are then given a pickle of approximately 1 min. in a 2 per cent. sulphuric aqueous solution, a water rinse and a 1-min. immersion in a chrome-pickle bath, followed by rinses in cold and hot water. The chrome-pickle solution contains 1.5 lbs. of sodium dichromate and 1.5 pints of concentrated nitric acid per gall. This treatment affords protection against corrosion during storage and provides a suitable paint base for subsequent painting.

Alloys

The bulk of the magnesium sand castings produced in this country are made from the two compositions listed in Table II. They appear to be meeting most of the service requirements put upon them in an increasingly wide range of applications. However, new compositions can be expected to be developed in response to changing needs. As an example of such development, methods have been perfected for the control of iron contamination in the casting alloys listed in Table II to less than 0.005 per cent. If other and more easily controllable impurities also are held to low values, the salt water resistance of magnesium alloys is remarkably good and applications formerly considered impractical become possibilities.

TABLE II.—*Compositions and Characteristics of Magnesium Sand Castings.*

Alloy.	A.S.T.M. alloy No.	Chemical compositions. Per cent. Al	Mn	Zn	Si	Other* impur. Max.	Mg.		Characteristics and uses.
C	17	8.3 to 9.7	0.10 min.	1.7 to 2.3	0.5 max.	0.3	Remainder	As cast Heat treated—HT Heat treated and aged—HTA	For castings requiring moderate strength and toughness. For castings requiring high strength and best toughness. For castings requiring high yield strength and hardness.
H	4	5.3 „ 6.7	0.15 min.	2.5 „ 3.5	0.5 max.	0.3	Remainder	As cast Heat treated—HT Heat treated and aged—HTA	For castings requiring moderate strength and toughness. For castings requiring high strength and best toughness. For castings requiring high yield strength and hardness and moderate toughness.

* Cu, max. 0·05 per cent. Ni, max. 0·03 per cent.

Note.—Alloy C is used for maximum pressure tightness and Alloy H is used for best salt-water resistance.

Typical Mechanical Properties of Magnesium Sand Castings.

Alloy.	Condition.	Tensile strength. Tons per sq. in.	Yield strength.* Tons per sq. in.	El. per cent. in 2 in.	Compressive strength. Tons per sq. in.	Shear strength. Tons per sq. in.	Rockwell "E" hardness.	Brinell hardness.	Impact Izod. ft.-lb.
C	As cast	10.7	6.2	2	22.8	—	68	60	1
	Heat treated	17.4	6.2	10	23.2	—	66	59	4
	Heat treated and aged	17.4	9.8	3	25.9	—	85	77	1
H	As cast	12.1	5.3	5	20.1	7.1	59	55	3
	Heat treated	17.0	5.3	11	20.5	7.1	60	55	5
	Heat treated and aged	17.0	8.5	5	22.3	8.0	74	70	2

* Yield strength is defined as the stress at which the stress-strain curve deviates 0·2 per cent. from the modulus line.

Electric Steel Furnaces

(*Concluded from page* 94.)

becomes very evident if one will remember that the electric furnace is a complete unit, requiring no gas producers, coke ovens or oil tanks and pumps to serve it. Interest on invested capital, property taxes and maintenance of this auxiliary equipment must also be taken into consideration.

Recovery of alloys is an important item. Under any of the practices mentioned, the residual alloys will be higher with a given carbon content in the electric than in the open hearth. For example, it is routine practice to melt vanadium scrap with the two slag practice and obtain 50 per cent. recovery. At the present price of $2.70 per lb. of vanadium, this is no small item. Chipping costs will invariably be much lower on electric furnace steel. Comparison of chipping costs with some open-hearth plants making comparable grades of steel show $2.00 per ton favourable balance. It is quite safe to say that generally there will be an increase in the overall yield of electric furnace steel amounting to about 5 per cent. Taking all these factors into consideration, it is quite evident that profits are made on the cost of the steel to the shipping department and not on the cost of the metal in the ladle.

It should be remembered that this comparison, like all others heretofore, has been made between a small tonnage of electric furnace steel and tremendous tonnages of other kinds. The savings possible in supervision, labour and maintenance costs in an electric furnace shop having the capacity of the large open hearths with from ten to twenty furnaces, is somewhat a challenge to one's imagination.

Principles and Practice Involved in the Production of Steel Castings*

By D. CLARK†

STEELMAKING

Since the greater number of steel castings produced in Australia to-day are made by the electric and converter processes, it is proposed to deal with these two methods only.

Electric Process

In the production of steel for forgings by any of the recognised steel-making processes, the necessity for using good quality scrap to ensure the best results is being constantly stressed. One rarely, if ever, hears, however, the same recommendation tendered in respect of steel for foundry use. Why, it is difficult to understand.

There is an old Sheffield saying, "Put the devil into the pot and you get the devil out of it," and there is not the slightest reason why the "devil" should be considered good enough to go into a sand casting and not good enough for an ingot intended for forge or mill. On the contrary, experience clearly shows that a heat of steel which proves quite satisfactory when cast into an iron ingot mould and forged or rolled, may be quite unsuitable to produce a saleable steel casting poured into a sand mould. Provided an ingot mould is clean and dry, no harmful reaction may result even if the steel poured into it is only reasonably quiescent. On the other hand, a refractory moulding sand is such a mixture of chemical constituents that if there is the remotest trace of reaction in the steel at the point of pouring, such will definitely be accelerated or aggravated when brought into contact with the mould facing. Great, therefore, as may be the urge to key up to the highest efficiency in making steel for forging production, there is need for a still greater urge in producing super-quality steels for sand castings and dissipating the widely-held belief that steel making for foundry requirements does not require at least equally meticulous care. A suspect heat cast into an ingot mould may go to forge or mill, as the case may be, without serious repercussions, but in the case of an intricate casting perhaps taking many days to mould the monetary loss would be heavy.

The type of furnace most favoured in Australia as elsewhere is the three-phase three-electrode Héroult, and for purely foundry requirements varies from 1½ to 7 tons capacity. The largest electric arc furnace in the world to-day is at the works of the Timken Roller Bearing Company, Canton, Ohio, where they have a 100-ton unit with six electrodes. Virtually it is two furnaces in one shell.

The electrode control of arc furnaces until recently was electric, but some recent installations have indicated a possible change-over to hydraulic. This latter control has proved to be very sensitive, but apart from the dangers attendant upon having hydraulic equipment so close to a melting unit, it is possible that when certain faults associated with existing designs have been remedied, there may be a gradual change over to this type.

A much more important and far-reaching development because of its greater influence on costs is, however, the introduction of the movable roof designed for rapid charging.

There are two such methods extant, one designed to lift roof and electrodes by means of a bridge crane, while the other employs a hydraulic cylinder enabling them when raised to be swung out of the way. Some of the large plants abroad charge their arc units by mechanical chargers in the same manner as Siemens furnaces. This, however, in the case of an electric furnace does not permit loading above the sill level, whereas in the case of the movable roof the complete charge can be placed in at one operation. By far the best method of introducing the charge is by placing the materials in a cylindrical box, made by welding plates together to form the shell, then have a number of hinged steel strips 3 in. or 4 in. wide radiating from the shell wall and tied together at the centre by means of a hemp rope. When the cylinder containing the charge is placed in the furnace the rope burns, after which the shell is slowly raised and the contents gently deposited upon the hearth. A 6-ton furnace can be charged in this way in about 3 mins., not only reducing heat losses thereby, but effecting considerable savings in refractories.

During the war and for a number of years thereafter, the practice was to refine under a carbide slag. While some plants still perpetuate this practice, the tendency nowadays is towards a purely white slag with a higher lime content rather than the typical carbide type more greyish in colour. The essential difference between the constitution of the two slags is that the purely white one carries less crushed coal or anthracite than the other; that is, less than is necessary to form calcium carbide. One advantage accruing from the latter practice is better control of the carbon content in the steel, while another is that the steel tends to exhibit a higher inherent fluidity. The importance of this for castings cannot be overstressed.

It must be candidly confessed that the physical chemistry of steelmaking, particularly on a basic bottom, is very complex, so much so that as yet it is not greatly understood. Stated broadly, the aim of a steelmaker should be to produce a steel with the highest inherent fluidity at the lowest temperature possible. It will be agreed that the solubility of molten steel for gas, increases as the temperature, which explains why superheated steel is always more difficult to kill. Once the bath has passed a certain temperature, the quality of the metal is impaired, and nothing done subsequently will ever completely rectify it. This aspect is most important in electric steelmaking, due to the unlimited power available, which if not wisely harnessed may easily prove dangerous.

The problem of fluidity and the influences determining it have been, and still are, the subject of a great deal of research by the Steel Castings Research Committee of the British Iron and Steel Institute. This work is particularly important in so far as the basic electric process is concerned, since it is a well-known fact that such steel is much less fluid at a given temperature than that obtained from the converter. A likely explanation is that the latter steel contains dissolved oxides, which evolve heat due to their reaction with manganese and silicon. Assuming this to be correct, then it follows that saturating electric steel with deoxidisers is bad and likely to produce a steel of such high viscosity as to render it unsuitable for castings, other than those of very heavy section.

Developing this theory still further, it might be postulated that after the deoxidants have been added it should be tapped quickly, and under no circumstances kept stewing in the furnace. The following of this procedure should ensure a steel with a problematical oxide content thereby enhancing its fluidity. The steelmaker's task is not, however, rendered any easier since it is his responsibility to determine the correct end point.

Influence of Zirconium in Steel

Much has been written about the influence of deoxidants other than manganese, silicon, and aluminium, such as titanium and zirconium, and the experiments conducted in the author's works with the latter metal a number of years ago, but not before published, are interesting. Eight foundry heats were made to the same specification, and to four of them ferro-zirconium was added, and Table I shows the chemical composition of the heats concerned and the physical tests obtained from each.

A scrutiny of these data shows clearly that there is a slight reduction in yield and ultimate stress on the zirconium treated heats, but quite an appreciable increase in elongation and reduction in area value. It is evident from this experiment that zirconium exerts considerable influence and the probability is that its effect is to reduce the undissolved gas content.

Influence of Gases

Further investigation, however, on this complex problem of fluidity in electric steel may yet prove that hydrogen and nitrogen are factors as well as oxygen. In connection with nitrogen, it is interesting to record that Prof. Andrew, of Sheffield University, has, as a result of experimental work, proved that the elimination of blowholes in steel can be achieved by the addition of iron nitride to the molten metal in such amounts that no nitride remains in the steel. The conclusion of these experiments will be watched with interest.

Referring to hydrogen, the author is not aware that much has been done to gauge what influence this gas has on steel quality beyond some perfunctory attempts to determine experimentally the percentage present in certain heats. It is possible, however, that this element may not be unconnected with blowholes on steel castings—particularly green sand ones—absorbed as a result of dissociation of water from the mould.

Proof of the modern foundry's ability to progress is shown by the fact that many foundries have introduced the latest development in electric steelmaking. Reference is made to the high-frequency furnace. For the manufacture of stainless, heat-resisting, and magnet steel of the nickel aluminium variety, this type is peculiarly suited. An important feature of the operations is that it is possible to remelt high-alloyed scrap containing nickel, chromium, molybdenum, tungsten, etc., with little or no loss, and in this respect it compares more than favourably with any other melting process, including even the coke-fired crucible. No other method of steelmaking yet devised for the manufacture of complex alloy steels ensures such an intimate mixing or emulsification of the constituent elements as the high frequency due to the turbulence set up in the bath by electro-dynamic action. In this furnace, steelmaking problems are reduced to a minimum and, now that the probationary period has been passed, foundrymen are certain to witness a steady growth in production the world over.

A new method of de-phosphorising and deoxidising steel which may eventually prove of considerable economic value in the foundry industry is a French process by Perrin. In the case of high phosphorus content, the steel is intimately mixed with a basic slag of such analysis that it will chemically combine with the phosphorus. To deoxidise, the means employed is exactly the same, except that an acidic slag is used to absorb the oxygen. The *modus operandi* is to heat the slag slightly in excess of the temperature of the steel, place it in a ladle into which the steel is dropped from a height of about 10 ft. This produces at first an emulsion of slag and steel, and, when the reaction

* Extracted from the Proceedings of the Australian Institute of Foundrymen.

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Production of Steel Castings

has ceased, the slag floats to the surface and is then raked off. The speed of the reaction is such that it is stated a 15-ton charge can be treated in 1 min. The resultant metal is said to be very free from non-metallic inclusions. The method can be applied to the open-hearth, converter or electric processes.

Converter Process

There are three such processes in existence:—(*a*) The original bottom-blown type bearing the inventor's name, "Bessemer"; (*b*) the "Stock" oil-fired unit; and (*c*) the "Tropenas," which is the process now universally employed in general foundries. It is proposed to discuss the last named only. The Tropenas converter is particularly attractive in foundries where the general character of the work is such that a regular flow of metal, say in 30- or 35-cwt. batches at comparatively short intervals, is essential. To make it economic, the converter should blow at least six heats per day. The manufacture of steel is a two-stage process. First, melt the charge in a cupola and tap it into a ladle; secondly, transfer the molten iron to the converter, where it is oxidised by means of an air blast to remove major impurities.

TABLE I.—*Influence of Zirconium on the Mechanical Properties of Steel Castings.*

Heat No.	Analysis. C	Si	Mn	P	S	Tensile Test. M.S. tons per sq. in.	Yield tons per sq. in.	El. per cent.	R.A. per cent.	Bend.
Heats without Zirconium.										
7771	0.16	0.26	0.61	0.041	0.044	29.3	17.5	27.0	36.6	O.K.
7773	0.18	0.25	0.55	0.039	0.048	29.7	18.9	31.0	29.7	O.K.
7777	0.16	0.24	0.64	0.041	0.048	26.9	17.9	36.0	47.5	O.K.
7780	0.20	0.32	0.74	0.040	0.032	31.5	19.0	24.5	37.2	O.K.
Average ..	0.175	0.27	0.64	0.040	0.043	29.4	18.3	29.6	41.1	
With Zirconium.										
7774 35 lbs. ..	0.17	0.36	0.63	0.019	0.038	27.5	17.1	35.5	49.8	O.K.
7776 40 lbs. ..	0.14	0.20	0.56	0.028	0.041	26.3	16.7	36.0	49.8	O.K.
7778 56 lbs. ..	0.21	0.43	0.62	0.025	0.032	30.3	16.7	32.0	45.0	O.K.
7786 56 lbs. ..	0.18	0.24	0.79	0.038	0.035	31.0	16.8	35.0	59.2	O.K.
Average ..	0.175	0.31	0.65	0.027	0.037	28.8	16.8	34.6	50.9	

In the early days of the process, considerable percentages of pig-iron formed the basis of the cupola charge. This has been largely replaced by steel scrap and to-day as much as 90 to 95 per cent. of the latter is being used. The substitution of steel scrap for pig-iron leaves a deficiency of silicon and manganese generally. This is compensated for by the addition of ferro-silicon to bring the silicon to 1.75 to 2 per cent., and ferro-manganese to raise that element to about 1 per cent. Carbon is absorbed as the melted metal passes through the bed of incandescent coke forming the fuel.

The amount of coke required when using steel scrap represents approximately a ratio of 1 to 6. For slagging purposes, 4 to 5 per cent. of limestone with a certain amount of fluorspar is added. It is desirable to add the charge in stages, say half the coke, limestone, fluorspar, and scrap, followed by the balance of the coke, limestone, fluorspar, and on top the remainder of the scrap and pig-iron. The class of coke employed should be of good quality and as much as possible in fairly large and more or less uniform pieces. It should be as low in sulphur as possible and preferably not above 7 per cent. in ash.

Since sulphur is a deleterious element in steel and amounts as high as 1 per cent. may be present in the coke, a method largely in vogue to-day designed to reduce the sulphur in the cupola metal is to add 2 or 3 lbs. per ton of soda ash. It is placed on the bottom of the ladle into which the cupola metal is poured. The reaction causes a more or less violent ebullition and the slag formed is removed before transferring the metal to the converter.

The blast pressure, which on the introduction of this practice was from 3 to 4 lbs. per sq. in., has on some modern plants been reduced to 1½ lbs. with beneficial results. A better blow and a cleaner steel is claimed, while the erosion of the lining is less severe. Melting losses under reduced blast conditions are 7 to 8 per cent., which, with the usual cupola loss of 5 per cent., brings the total to 12 to 13 per cent.

The amount of metal from the cupola which can be added to the converter is governed by the angle formed between the line of the blast and the surface of the metal, usually about 12 deg. from the vertical. After blowing has proceeded for a time, the vessel is brought back until the angle is reduced to 6 deg., the tuyeres always being above the metal level. When the metal blows cold, it is necessary to add a quantity of ferro-silicon to the vessel, by which means the temperature is increased from the resultant exothermic reaction. Conversely, if the metal is too hot, a most undesirable condition, it may be cooled by the addition of cold scrap, but such a heat rarely proves of good quality.

Moulding Sand

Foundries fortunate enough to be on repetition work have few problems, since one class of sand adequately fulfils their requirements. Those plants, however, whose production is of a varied character not only with respect to types of steel, but of castings, may have many diverse conditions to meet. For example, they may be producing light, medium, and heavy castings, where the facing sand must be graded to withstand temperature variations arising from the differential freezing of thick, medium, and thin sections. Moreover, on particular castings containing in themselves both heavy and light sections, the problem resolves itself into the difficult one of providing a sand that will be refractory enough for the heavy parts and yet not so strong as to produce rupture during contraction where linked to the lighter sections.

The initial cost of the sand is, and must always be, important. What is of greater importance, however, is the quality and appearance of the finished casting and no savings accruing from a low sand cost are justifiable if to make a casting saleable or presentable excessive money has to be spent in the dressing shop.

As is well known, the essentials of a good foundry facing sand are as follow:—

(*a*) Sufficient silica with the minimum amount of alkalis to ensure the necessary refractoriness.

(*b*) It must be sufficiently strong not only to withstand handling, but the scouring action of hot metal during pouring.

(*c*) Sufficient permeability to permit the passage of the first flush of gas as the metal enters the mould.

(*d*) The property of accommodating itself to the linear contraction of the metal while cooling.

(*e*) It must strip easily and well, leaving a good skin on the casting.

Continental foundries to a very large extent employ natural sands, such sands being for the most part of good quality and comparatively cheap. Unless, however, under exceptionally favourable conditions, they are at times irregular in composition and character and therefore require constant and close scrutiny if variations in quality of the castings are to be avoided.

Synthetic sands, on the other hand, are more readily controllable, and therefore more regular in properties and quality, particularly if the base employed is well-weathered, wind-blown beach sand, which has the outstanding advantage of being consistent in chemical composition. Whatever binder is used with such a base, it should be as finely divided as possible and of low specific gravity, *i.e.*, bulky in proportion to its weight, so that the smooth grains of the facing sand will be evenly and thinly coated.

In choosing a sand to make a mould, the method of running should be taken into account. There are three methods by which a casting may be poured, namely, top, bottom, or on a bank. When poured from the top, the sand must have sufficient strength to prevent disintegration resulting from the impact of the metal, and if poured down or up a bank, it has also to be strong, refractory, and preferably smoothly finished to withstand erosion, particularly in the case of castings of some length. The ideal facing sand is one permeable enough to permit the passage of gas and air arising from the first inrush of metal, and refractory enough to prevent burning in.

As the permeability is a function of the size and shape of the grains it would obviously be unwise to make the sand too permeable, otherwise the surface of the casting may have a roughened appearance, due partly to the imprint of individual grains, and partly to the interpretation of the metal between the grains, particularly in the case of steel of high fluidity.

It is also important to remember with respect to permeability that it does not apply to facing alone, but also to the backing sand. This should be somewhat more porous than the former, so that throttling of the early gases percolating from the surface may be prevented. In moulds with a backing sand less permeable than the facing, the gases may be baffled and pushed back again through the face into the metal causing pinhole troubles.

If such difficulties are to be avoided, the necessity for paying strict attention to the properties of the backing sand by removing silt, will be appreciated.

Referring to the question of moisture, particularly for dry sand work, it cannot be overstressed that the percentage of water added should be no more than will enable the sand to pack satisfactorily, so that the mould will faithfully conform to the pattern. To ensure regularity from batch to batch, the water should be measured, since excessive moisture takes time and heat to drive off.

Second only in importance to the composition of the sand itself is the milling operation, the function of which is to intermix thoroughly the ingredients and effectively coat the grains with the binder. The weight of the rollers is important, and heavy units ought not to be employed as the grains should not be crushed or broken up. Rubber faced rollers are excellent for this purpose.

Since the sand and its properties exercise such a decisive influence on foundry operations, increasing attention is being paid to routine testing for moisture, permeability, green and dry strengths on facing, and permeability tests on backing sands. The importance attached to this may be judged from the fact that one large

Production of Steel Castings

British foundry makes hourly tests, and while this may be more often than necessary on most plants, no foundry with any pretence of progressiveness should be without the necessary equipment to enable such tests to be made at regular intervals.

To ensure satisfactory results, experience has indicated that a permeability range assessed by the standard A.F.A. apparatus, of 125/175 for facing and 175/225 for backing sand is quite good.

Design, Moulding, and Machining

Successfully to produce steel castings, the following fundamental facts must be appreciated not only by founders but also designers:—(*a*) That steel contracts superficially and volumetrically; (*b*) that gases are evolved; and (*c*) that its several constituents do not exist in solid solution but are segregated to a certain extent.

Disabilities arising from these factors may be summarised as follow:—(*a*) Hot tears and surface stress cracks from superficial or linear contractions, and cavitation from reduction in volume; (*b*) blowholes caused by entrapped gases; and (*c*) brittleness liable to induce internal rupture under stress.

One of the phases governing the extent, nature, and incidence of these disabilities is the temperature at which the steel is poured, and herein lies one of the major differences between providing ingots for forging or rolling on the one hand, and castings for, say, a jobbing foundry on the other.

With steel destined for ingots, the range of temperatures can be kept to very narrow limits irrespective of sizes, but for sand castings one has to take into account the number to be poured and whether the majority are thick or thin in section. The lowest temperature possible is always desirable, particularly for thick jobs, but where there are a number of thin walled castings to be poured the temperature has to be increased. In many instances, therefore, a compromise has to be made, but the aim of the steelmaker should always be to provide metal of the highest degree of fluidity for a given temperature, which should never in any circumstances be higher than is absolutely necessary.

When steel is poured into any mould, the thickness of the initial skin formed is a function of its temperature combined with the degree of chilling effected by the mould surfaces. The first physical change naturally takes place at the surface which, if tension cracks other than those occasioned by faulty design are to be avoided, should be strong enough to withstand the stress resulting from the reduction in linear dimensions and in the case of a heavy section the adverse volume phase changes taking place later. Since the actual pouring temperature determines the interval between the liquid and solid phases, it is obvious that a high temperature will produce an initially thin and more or less brittle skin, while descending temperatures will provide increasingly thicker and therefore stronger surfaces as first formed.

It has been mentioned that blowholes are caused by entrapped gases, and a favoured position for the imprisonment of such gases is at corners and particularly re-entrant angles. In aeronautical, motor vehicle, locomotive, and marine work increasing attention is paid to streamlining for the purpose of minimising wind resistance, and there are many instances where designers could profitably adopt similar ideas in the design of castings. A streamlined casting is one that should have all corners sweetened and be reasonably free to respond to contraction without being anywhere bound.

In designing a casting the first consideration surely is to produce a picture of something a foundryman can reasonably be expected to make, and that, from a metallurgical standpoint, will be sound. How often is it, however, that a designer produces a drawing solely from what he has arrived at by computing known stresses, guessing the unknown, and amendments are only made when the founder has failed to produce a satisfactory job.

Broadly, the requirements of a well-designed casting are: Amply radiused corners, gradual mergence of a heavier to a lighter section, and the elimination of the necessity for employing thin wedges of sand in any part of the mould. However, the necessity for co-operation between designer and moulder has been stressed on so many occasions that it is not proposed to belabour it further, except to suggest that similar co-operation might profitably be extended to the machinist who, after all, is the last man to handle the job and whose task is sometimes made more difficult than need be. Moreover, machining contributes its quota to the cost of a casting, hence the desirability of widening the sphere of co-operation to include this phase of the production.

Observations on many plants have not revealed much evidence of that co-ordination of interests between the moulding and machine shops that should exist if the foundry industry is to attain the highest efficiency. If the machinist had a more intimate knowledge of the moulder's problems and the moulder of the machinist's there are doubtless many occasions when they could be mutually helpful. Without a sympathetic and at the same time intelligent appreciation of each other's difficulties no real progress can be looked for.

Early Precautions

Before deciding how to mould a casting not encountered before, it is a wise precaution to give a little thought to alternative methods of moulding. Having agreed upon a plan of attack, it is desirable to prepare a sketch on which should be noted thereafter the type and extent of any difficulties found, and the corrective measures to be taken when next making the same casting. Careful records kept in this way are well worth while, and indeed necessary to any foundry desirous of building up a reputation for sound, reliable work. Allowing for the influence the condition of the steel has in determining the quality of any casting it cannot be gainsaid that the actual make-up and condition of the mould itself, together with the method of pouring, has at least as great a bearing. Increasing attention is being given to mould densities, the importance of which cannot be overstressed.

The density of any mould is governed by four factors, namely, the percentage of bond, the grain size of the sand, its moisture content, and amount of ramming given. These four points determine in turn the mould's permeability or capacity to conduct away the gases formed during pouring. To ensure a good skin on casting, the mould face should be close rather than open. This on an inherently open sand can be assisted by use of a suitable face wash. On a closely compacted face, only the thinnest layer of wash is necessary, whereas a more open facing sand of high permeability requires a heavier coating, for the reason that there are more voids to fill. An obvious and serious disability of the latter practice is, however, that if the surface film is too thick it will exhibit a tendency to flake when subjected to the sudden impact of heat consequent upon the act of pouring.

Running Castings

With regard to the running of castings it can truthfully be said that no part of a founder's job exceeds in importance that of the runners or gates employed, since improper running is definitely responsible for a large percentage of the troubles encountered in any foundry. Not only has the proper point of entry to be chosen, but the area of the runners must be fixed in accordance with the weight and design of the casting. To achieve successful results the runners should not be restricted at the mould opening, but rather enlarged, so that the metal may flow quietly and at minimum pressure. In other words, there must be no semblance of the nozzle effect of a water hose, as metal squirted into a mould under pressure will always cause erosion of the mould faces and produce dirty surfaced castings. Where basins or tundishes are provided they should always be kept full so that the runners may also be full and thus prevent air being sucked in with the metal.

The desirability of having a fairly close rather than open facing for the purpose of ensuring good surfaced castings has been mentioned. This, however, might cause trouble unless the backing sand has a permeability slightly in excess of the facing, and the mould is well vented. The importance of ample vents positioned at what we might call strategic points cannot be overstressed, and while no harm other than possibly a weakening of the mould can accrue if overdone, needless repairs or even wasters may result if scamped.

Defects in Steel Castings

Turning now to defects found in steel castings, probably that which gives rise to most heartburning is the presence of cracks caused by hot tearing. As the steel cools from the molten state, its strength gradually increases. At the same time, however, it is contracting, and if the mould is too strong to permit being crushed by the shrinking steel then the castings will simply tear at the weakest point.

Apart from the employment of green sand where the weight of the casting permits this practice, there are three methods by which this may be overcome. First by easing the mould quickly enough at vital points so that it may accommodate itself readily to the contracting steel, secondly by using weaker sand, *i.e.*, one that will just hang together until the metal is set, and, thirdly, by increasing the strength of the steel at high temperatures by the addition of alloys. Since the last-named methods involve increased cost, it is not always permissible and the remedy therefore lies in the adoption of either the first or second alternative.

(*To be continued.*)

The Acid Resistance of Finished Enamelware

(*Continued from page* 98.)

disintegration of the enamel begins, the colour intensity often diminishes, and although the texture of the surface is different, this is not recorded in a photograph. Secondly, although a photographic standard would be suitable for black stains on white enamels, or white stains on black enamels, it could not give results of any absolute significance when dealing with other colours, either of enamel or of colour oxide. Even for black and white, the appearance is greatly affected by the printing and photographic processing, and could only be used as a rough guide or comparison.

(*To be continued.*)

A.S.T.M. Specifications for Copper Alloys

A.S.T.M. Committee B-5 on copper and copper alloys, cast and wrought, recently submitted fourteen new specifications, two new methods of test, and recommends revisions in twelve tentative standards, the immediate revision of six standards, and the adoption of one tentative standard as standard. Of the fourteen new specifications, seven cover sand castings of widely-used copper alloy compositions covered by the ingot specifications already issued. The remaining seven specifications cover various wrought copper products, including leaded red brass (hardware bronze) rods, copper sheet and plate, aluminium-bronze rods, copper-nickel-zinc alloy rods, phosphor bronze rods and wire, and manganese bronze rods. The new methods cover procedures for the expansion pin testing of copper-alloy tubing and the mercurous nitrate test for copper-base alloys.

Electric Steel Furnaces*

ECONOMIC CONSIDERATIONS

The economics of the electric furnace for steel making was recently considered in a Paper presented by MR. H. E. PHELPS to the Detroit Section of the American Association of Iron and Steel Engineers. The author states that after many years of research, furnace makers have now standardised two basic types, the three-phase direct arc and the induction furnaces. The induction furnaces are relatively few and of small capacity, and are used chiefly for special work. All of the tonnage steels are made in the direct arc furnace and the preponderance of this type of furnace is so great that, in speaking of electric furnaces, the direct arc type is generally inferred.

Arc Furnace

This furnace is essentially a steel shell, usually cylindrical, mounted upon a tilting device and lined with a refractory material. A carbon or graphite electrode at each phase conducts the current into the furnace, where it arcs from the electrode to the metallic charge and from the metal back to one of the other electrodes. These electrodes are raised and lowered by means of motor-operated winches automatically controlled by means of contact-making ammeters. This control is quite sensitive and will regulate to plus or minus 500 amperes when arcing to cold scrap and to plus or minus 100 amperes when arcing to the molten bath, thus giving the operator very close control of temperature.

A modern furnace cited by the author is 18 ft. in shell diameter, 10 ft. 6in. in height of side plate and with the fore plate about midway in the side plate. It is powered with a 10,000 k.v.a., 40 deg. rise transformer, with five secondary taps; 275, 240, 185, 140 and 105 volts. The three highest taps are connected delta-delta and the two lower ones star-delta. The normal rated capacity of the furnace is 50 tons, and the average heat tapped is about 56 tons.

Perhaps the greatest single advantage of the electric furnace over other types lies in its great flexibility. It is the only melting medium in which it is possible to produce the highly oxidised product of the Bessemer converter, the refined and partially deoxidised product of the open hearth and the completely deoxidised and highly refined electric furnace steels of to-day, and even improve upon the cupola and air furnace in the production of grey iron and malleable. It is possible to produce each of these metals in successive heats without any change in the furnace and without loss of quality in the product. Like the open hearth, it may be lined either acid or basic.

In the plant with which the author is connected it is regular practice to make the three types of steel mentioned. This means an extremely wide range of deoxidation practices; from slags containing 25 to 30 per cent. FeO in the case of some of the Bessemer types and rimming steels, down through the range of 10 to 14 per cent. FeO in the case of the open-hearth alloy steels to the extreme low of 0.25 per cent. FeO or less for aircraft quality electric furnace steels. Thus, it can be seen that any steels that can be made in the open hearth or Bessemer can be made in the electric furnace, but there are a number of grades that up to the present have been made successfully only in the electric furnace. It can be truly said that the electric furnace is the one and only universal furnace for ferrous melting.

Flexibility of the Unit

The flexibility of the electric furnace is as outstanding and important from the standpoint of operations as it is from that of product. All plants have the problem of part-time operation in dull times. When it is necessary to shut this furnace down over week-ends, there is no skeleton crew on "gas turn" and no fuel consumed in merely keeping the furnace hot. Instead, all fuel cost ceases immediately after the last heat is tapped. As soon as the ordinary bottom repairs are made, the doors and electrode glands are sealed and, within an hour of tapping, all labour costs have stopped. The only extra cost entailed by a shut-down of a day or week is that of a few extra kw.-hrs. per ton on the first heat made upon the resumption of operations.

Immediately after having tapped a heat, the furnace is brought back from its tapping position, which is a forward tilt of about 45 deg. to its extreme backward tilt, which is generally in the neighbourhood of 18 deg., so as to afford the operator a good view of the hearth. Should there be any holes in the bottom, they are repaired in the same manner as in the open hearth; that is, by rabbling the steel out of the holes or blowing it out with compressed air and then filling in the holes with dolomite or some other refractory. This having been done, the electrodes are raised to their maximum height and charging is begun by means of the conventional open-hearth charging machine. A great deal more care must be exercised in placing the scrap properly to charge the electric furnace than is necessary in the open hearth. It is important to get as much scrap as possible in the furnace on the first charge, since the power must be taken off in order to recharge, whereas all charging may be done in the open hearth with the flame on. For fast and economical melting, the furnace should be charged more heavily opposite the electrodes than elsewhere, otherwise these hot spots will be melted out first, with the result that the power input must be decreased to prevent excessive wear on the furnace lining. All heavy scrap must be placed near the bottom to prevent electrode breakage when the charge slips down, for since the electric furnace melts from the bottom up, any scrap charged above the fore-plate line will have to fall into the bath. Limestone charged must be so placed that it will not come under the electrodes, otherwise a broken electrode would result, due to the limestone being a non-conductor. Finally, there is only one charging door, which means that after the furnace has been filled to the fore-plate line, any additional scrap must be pushed and rolled back in order to fill the furnace. Incidentally, it is really astounding the amount of scrap a good machine man can get through one door, and when he has finished, one wonders how he managed to empty the last box.

The furnace having been charged, the current is switched on at maximum voltage and current, in the case under review at 275 volts and 34,000 amps., the electrodes put on automatic control, and started on their way to the bottom. By the time they have melted down through the scrap to the bottom, they have formed a pool of metal on the bottom and arcing continues to this ever increasing pool until all the charge is melted. Shortly before melting is completed, a preliminary test for carbon and phosphorus is taken so that adjustments can be made and the proper carbon and phosphorus content had by the time the heat is ready to be slagged off. Should the carbon be too high it is reduced by means of mill scale or iron ore as in the open hearth: should it be too low it can be increased by the addition of pig-iron or by the simple expedient of switching off the power and immersing the electrodes in the bath for a few minutes. The proper carbon and phosphorus having been obtained, the heat is ready for finishing by any of the following means:—

(1) Melting with oxidation, removing the oxidising slag and making a second and de-oxidised slag; which is the most common practice.

(2) Melting with as little oxidation as possible and changing the melt-down slag to de-oxidising without removal.

(3) Melting and finishing either with one or two oxidising slags and controlling the FeO content.

Melting High Alloy Scrap

The second method is used in melting high alloy scrap, such as high-speed steel, etc., where the value of the alloys is of paramount importance. It is the slowest of the three practices mentioned, but 100 per cent. recovery can be had of any alloy in the scrap. This is important when remelting 14 per cent. tungsten scrap for instance, with tungsten selling currently for $2.50 per lb. It is perhaps unfortunate that this practice will also yield 100 per cent. recovery of the phosphorus in the scrap, so that assurance must be had that the content of this element is not above the specification. Practices Nos. 1 and 2 are in general use in the author's plant.

When the proper carbon and phosphorus have been obtained as mentioned before, the oxidising melting slag is removed from the furnace. This is accomplished by back-tilting the furnace slightly and raking the slag off by means of wooden rabbles. By the time this operation is finished, the laboratory will have reported the preliminary analysis and the additions of the various ferro-alloys are made to bring the bath within the specification. The lime and fluorspar for the second slag is then spread on the bath by the charging machine.

From this time on to tapping time, the success of the heat depends entirely upon the skill of the melter and the first helper. The method of working the slag to almost complete de-oxidation is purely empirical, for while many attempts have been made to develop a standard slag mix and technique, none has been successful. The methods and materials for making such a slag are perhaps as many and varied as there are plants. The lime may be de-oxidised by carbon in the form of coke breeze or powdered petroleum coke to form a calcium-carbide slag, by the addition of some form of silicon to form calcium silicate or by aluminium to make a calcium-aluminate slag. Each method has its good points and each its drawbacks, so that it is largely a matter of individual preference. When the slag is de-oxidised, a second preliminary test is sent to the laboratory and upon receipt of the determination, final adjustments of analysis and temperature are made and the heat tapped.

A log of a typical two slag heat is given in the original article.

The fuel cost, that is, the sum of the electrode and power fuel cost, on a 50-ton furnace is about $6.00 per ton. This is the largest single item and is roughly three times that of the open hearth. This is largely compensated for by other savings. First of all comes the melting stock. The usual charge of an open hearth making alloy steel is 50 per cent. scrap and 50 per cent. pig-iron, and the electric furnace always uses 100 per cent. scrap. At current U.S. quotations this is a saving of $1.50 per ton. Refractory costs for the electric are in the neighbourhood of 20 cents per ton, which represents a saving of at least a like amount over the open hearth. Maintenance is much lower, and operating labour no higher. Interest on invested capital and property taxes is a big item, for a 50-ton electric furnace costing about $120,000 will make about the same tonnage as a 150-ton open hearth costing many times as much. This saving

(*Continued on page* 90.)

* From "Iron and Steel Engineer."

Two Methods of Moulding a Drum Casting

By W. GUDGEON

With the majority of patterns, the method of moulding to be employed is indicated by their construction, and it is seldom that the moulder is instructed to make the job any other way. Only on occasions when it is discovered that suitable plant is not available or a mistake in the estimated cost of moulding has taken place is an alternative way of moulding the job called for in an endeavour to cut costs. The article below describes such an occasion, when, lacking a suitable moulding-box an alternative way of moulding the pattern other than its construction indicated was carried out as the small number of castings required did not warrant the making and fitting new box parts.

As will be seen by Fig. 1, the pattern as constructed suggests the use of a middle box, 17 in. deep, this middle part to be lifted away after drawing the pattern to enable the loose flange at the base of the mould to be removed. As there was no moulding-box on hand by which these operations could be accomplished an alternative way of making the job was to bed the pattern in the floor and using only a top part.

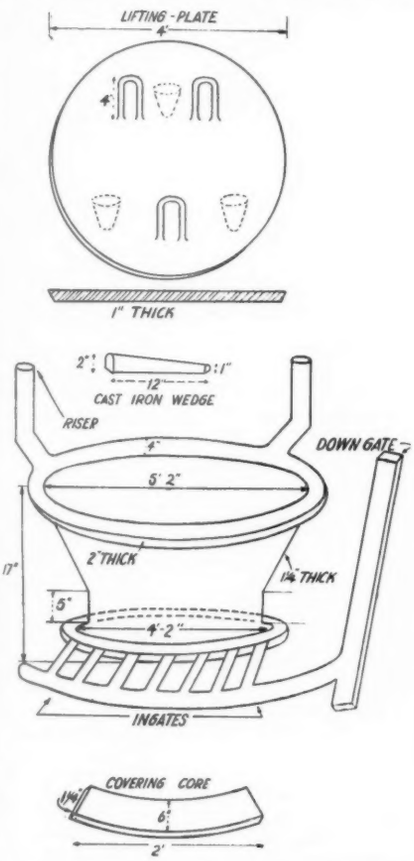

FIG. 1.—PATTERN FOR DRUM CASTING.

The dimensions of the casting are:—Depth, 17 in.; inside diameters, top 5 ft. 2 in., bottom, 4 ft. 2 in.; width of flanges, 4 in. by 2 in. thick, and the body of the casting, 1¼ in. thick. The mould was made in green sand, and the approximate weight of the casting is 14 cwts.

To mould the casting as here described, it was necessary to saw the bottom flange into eight parts to enable the moulder to withdraw them inside the mould. To accomplish this operation successfully a plate, 4 in. diameter and 1 in. thick, was cast to lift away the straight, 5-in., wall of sand, as indicated in the sketch.

Moulding Operations

The circular lifting plate is levelled on to a hard bed of sand, this being strickled off 6 in. past the plate. The width of sand is then well vented and prepared to receive the pattern, which is then set on to it and which leaves a margin of about 1 in. between plate and pattern. The eight pieces of flange are then fitted in their place against the pattern, rammed tightly at the back, and the sand strickled off level with the top of the flange. This is then covered with oil-sand cores, eight of these being used for the purpose with two more covering the seven ingates which have been previously cut. Ramming outside of the pattern is then proceeded with until the top flange is reached. A parting is then made inside the pattern, level with the lifting-plate, and the 5 in. of sand rammed hard, and another parting made at the point where the pattern begins to slope away. An inch of sand is then laid on the joint and a grid, specially made for the purpose and with its outside row of prods at the same angle as the pattern, and with its bottom side clay-washed is lowered inside of the pattern and on to the joint. The grid is shown in Fig. 2.

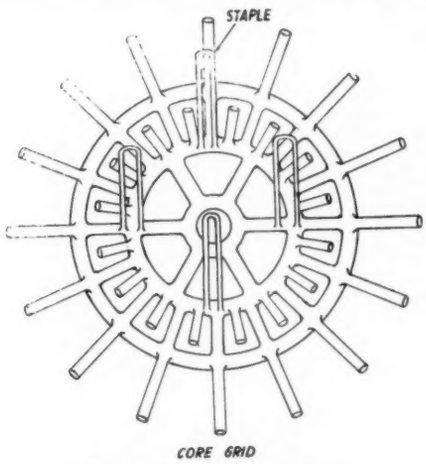

FIG. 2.—TYPE OF GRID USED.

The inside is then rammed carefully up to the top, the last joint made on the outside of the flange and the top part placed on. The four staples attached to the grid come through the box bars shown 2 in. above. A strong cast-iron wedge is driven through the loop of each of these, which secures the grid to the top part.

It is not advisable to attempt to turn over the top part as there is the danger that with the slightest sag of the grid the wedges may loosen a little and the grid swing out of place. If it were necessary to turn the top part over, as in this case it is not, there being no finishing worth mentioning, the grid would have to be placed prods down and bolted to the top part. This would mean much longer time being taken in gaggering and ramming through the grid.

With the top part of the mould finished the lifting-plate is hoisted out, the eight pieces of flange withdrawn, the moulder being able to work inside the mould to finish it. Six of these drums were successfully cast by this method.

Law Reports

Accident in a Foundry

Mr. Justice Cassels has given his reserved judgment at Manchester Assizes in a case in which Gordon Pollitt, ironmoulder, of Pendleton, claimed damages against his employers, James Hodgkinson (Salford), Limited, engineers and ironfounders.

Mr. E. J. Hemmerde, K.C., for Pollitt, suggested that an accident which occurred on September 6 last year and which resulted in Pollitt's sustaining a burned and permanently injured foot was due to the use of an unsound moulding box. Pollitt, he said, was casting stoker doors when molten metal flowed over his foot from a hole in a moulding box which had been covered with a sheet of metal and sand. There was, he explained, controversy regarding the claim of the company that Pollitt had received compensation under the Workmen's Compensation Act and was not therefore entitled to recover damages.

The moulding box in question was inspected by the judge and counsel. Pollitt said the foreman had told him to use the box with the hole in it, saying it would be all right if a piece of sheet metal were put behind the hole. Mr. H. Strange, consultant engineer, described the temporary repair as dangerous. Mr. Robert Yeomans, assistant manager of the foundry, for the defence, said he did not consider the practice described by Pollitt was dangerous. It was followed by all the foundries of which he had experience, but in this case after the accident there was no piece of metal found such as should have been used to cover the hole. Mr. T. C. Ormiston Chant, consultant engineer, described the use of a metal sheet to patch a hole in a moulding box as a safe and usual expedient.

Giving judgment, Mr. Justice Cassels said the foot was permanently injured and Pollitt was incapable of carrying on his work as an iron moulder. He had not been guilty of any negligence, and the injury was due to a defective system of the defendants. In this case the question arose whether a man who had received compensation under the Workmen's Compensation Act was precluded from obtaining damages at Common Law. He did not accept Pollitt's evidence that he had never heard of the Compensation Act until he saw his solicitor. He held that Pollitt received the payments from the company and that he received them under the Workmen's Compensation Act. He did not think he was inflicting any hardship upon Pollitt, as compensation under the Act would be paid as long as there was incapacity. Had he had to assess damages, he would have awarded £600. Judgment would be for defendants, with costs.

Mr. Hemmerde mentioned that there might be an appeal.

Contracts for Steel Sheets

In the King's Bench Division recently, the Lord Chief Justice awarded damages of £1,600 to Arthur E. Evans & Company, Limited, of The Minories, London, E.C., against the Llanelly Steel Company (1907), Limited, of Llanelly. Plaintiffs claimed with regard to breach or repudiation of contract for the supply of 400 tons of black steel sheets at £13 a ton. The original claim was for £3,200.

The contract was for the delivery of the sheets about April 15, 1940, at Llanelly or Swansea, and plaintiffs claimed that the goods could have been shipped for Liverpool that day, but defendants declined to proceed with the matter. The defence was a plea that the sheets were intended for Lithuania, and plaintiffs' export licence was cancelled before shipment could be made. Further, no vessel was made available in time to load the sheets, and had it been available it could not have been loaded before the licence was cancelled.

His Lordship held that the defendants had been guilty of an anticipatory breach of contract that rendered them liable to damages, and entered judgment for the plaintiffs with costs.

South African Export Ban

A prohibition has now been placed on the export from the Union and South-West Africa of all minerals and ores, and also manufactured goods consisting wholly or mainly of iron or steel. Export of certain classes of manufactured iron and steel goods will be permitted within limits upon the production of a certificate of essentiality and a guarantee that the country importing will not re-export.

The Acid Resistance of Finished Enamelware

RECOMMENDED METHOD OF TESTING

(*Continued from page* 12.)

Application of Solution

To devise a method of applying solution to, and maintaining it at, the enamel surface appears to be a simple task, but several factors had to be considered in order to arrive at a method sound in principle, yet simply and quickly put into use. First of all, methods which were known to have been in use for this purpose were considered.

Perhaps the simplest method is just to place a few drops of the solution on the surface of the enamel, then wiping or washing off after a given time. For best results, the enamel surface must be smooth and flat, so that a regular and sharply defined impression can be obtained. For use over a long period, protection from evaporation would be required.

A method commonly used is to soak a piece of filter paper in the testing solution and apply it to the surface of the enamel. This method, as it stands, has the disadvantage that uniform, intimate contact is not always obtained. Also evaporation takes place very readily, especially in a warm atmosphere, and this leads to an increase of acid concentration round the edges of the filter paper, the greater attack thus generally produced appearing exaggerated by comparison with the surrounding unattacked surface. For short periods this is, of course, less important, but at the stage when this was being discussed, no definite conclusion had been reached about time of contact to be recommended.

Another method that has been used in practice is to clamp a rubber bung on to the enamel surface, a hole in the bung containing the acid which is in contact with the enamel. This method works excellently with uneven and slightly curved surfaces, but the need for clamping on to the enamel gives rise to difficulties with some types of ware.

The use of a small glass cell attached to the surface, to contain the testing solution, requires a very smooth, flat surface. The only method of quickly attaching the glass cell by means of a non-leaking joint appears to be by a film of grease applied to the ground edge of the cell. The use of grease is to be avoided if possible, on account of the likelihood of contaminating the surface to be tested and thus preventing complete attack all over the area being tested. In any "spot" test, it is first necessary to remove any trace of grease from the surface to be tested, and to introduce grease after this involves the taking of special care in manipulation. A ring of plasticine appeared to offer a convenient method, but unfortunately this material is attacked and disintegrated by some acids, notably oxalic acid.

From experience with filter paper, it was thought that some other absorbent material, preferably of greater thickness, might prove useful as a contact medium, and avoid the difficulty due to evaporation. A piece of sponge gave only intermittent contact, cottonwool was difficult to handle when sufficiently moistened, while a pulp of paper and the testing solution had to be of very uniform consistency and rather critical liquid content for successful workability. Trials were also made with a paste made with ground quartz and acid solution (kieselguhr contains materials dissolved by acids), but again the consistency of this for satisfactory working was extremely critical and its tendency towards thixotropy was very inconvenient. All these absorbent materials tended to make uneven and ill-defined impressions on the enamel surface, although the use of a small glass cell to confine them led to some improvement.

Such absorbent materials were intended to act as a kind of reservoir of solution to minimise effects of evaporation of water and neutralisation of the acid by reaction with the enamel. It was a logical step to provide a separate reservoir of solution in constant communication with the absorbent material on the surface of the enamel. One method of achieving this is shown in Fig. 2. The solution is conveyed from the bottle by the wick (an ordinary round lamp wick enclosed in a glass tube) to the small round pad formed by opening up the fibres at the end of the wick for a distance of about ½ in. until the appearance of cottonwool is obtained. A second hole in the stopper can be closed by a glass rod, having a sliding fit, so that the flow of solution can be controlled. When not in use, the end of the wick is protected by a glass tube. With this arrangement, a test can be made at any time without further apparatus or materials being required. If appreciable reaction with the enamel occurs, the wick will be contaminated with the products of reaction, so that it is better to interpose a pad of filter paper between it and the enamel surface. Also for use over long periods, a glass shield can be fitted to prevent evaporation. From this it was attempted to arrange for the solution to be fed to the pad of filter paper by means of a fine glass capillary tube. It was thought that it might be possible to arrange this so that surface tension stopped the flow of solution when sufficient had passed over to wet the pad thoroughly. Unfortunately, the diameter of the capillary proved to be rather critical, so this method could not be recommended for general use.

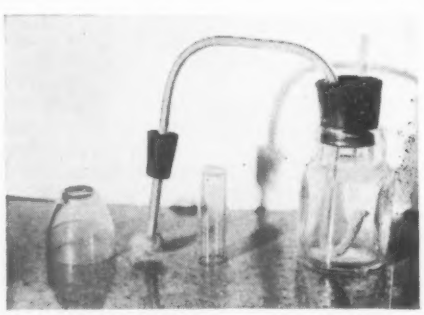

FIG. 2.—THE "WICK" METHOD OF TESTING.

All things considered, the popular filter paper method seemed to offer the advantages of simplicity, and it was considered that a suitable modification of this would probably be the most convenient for a "spot" test. To reduce the evaporation effect, a greater quantity of solution was used, this being best achieved by placing the paper in position dry, and adding the solution from a pipette or dropping bottle. A round piece of paper, rather than the usual rectangular or irregularly shaped piece, is better in this respect, while a thicker piece of filter paper (cut from a filter pad) of rather smaller diameter than the thin piece and placed on top of it, makes a further improvement. The general effect of the filter paper is then not so much to absorb the solution, as to hold together the large drop of solution on the surface. A regular, well-defined impression is made, which is of great assistance when deciding whether attack has taken place, as described later. For ordinary purposes, a circular piece of filter paper, 2.5 to 3 cm. dia., is recommended, the pad on top of this being 0.5 cm. less in diameter. The smallest size filter paper in common use, 4.25 cm. dia., is rather large for the average type of ware to be tested, but avoids the need for special ordering or cutting of smaller discs. With these precautions, filter paper is a satisfactory medium for applying the testing solution, when only a short time of contact is required.

Time of Contact.—A "spot" test is essentially a test which is simple and rapid, although these two factors must not be obtained at the expense of decisiveness and reproducibility. To determine a period of time which will be long enough to give consistent results and yet not too long, so as to make it inconvenient in use, tests were carried out on resistant and non-resistant enamels for periods of a few minutes up to several hours. From these it appeared that a period of half-an-hour was ample to ensure that any effect produced has practically reached a steady state, while 15 min. sufficed to establish whether there would be any effect or not, and allowed such an effect to be developed sufficiently for detection by the methods to be described.

Degree of Attack.—Having discussed the questions of what solution to use and how to apply it, there remains the question of interpretation of the results obtained. This will depend on the principle of the test. Thus, if one particular solution is specified, it becomes necessary to have a method of classifying the effects produced. The Sub-Committee considered that beyond a certain degree of attack, there was no point in having a different classification, and such enamels should be tested with a weaker acid solution. Similarly, if no effect is produced, the enamel should be tested with a stronger acid. Any "spot" test was considered to be essentially a "go or no-go" test, and its scope best widened by using several testing solutions.

Two Types of Effect

To decide whether a given solution has or has not produced a significant effect on the

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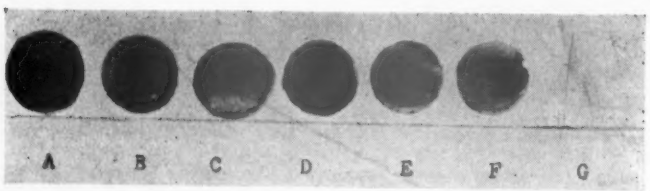
THE STANTON IRONWORKS COMPANY LIMITED, NEAR NOTTINGHAM

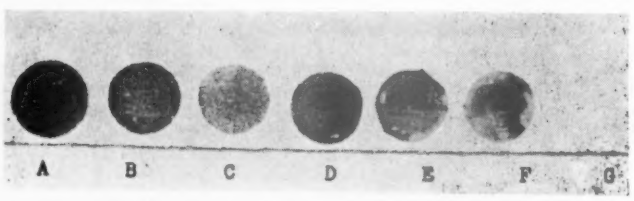
enamel surface is not so easy as it first appears, and considerable discussion took place on this subject. The chief difficulty arises from the fact that two distinct types of visible effect can be produced on vitreous enamel surfaces by the action of cold acid solutions. The first is the normal kind of attack, resulting in loss of gloss and, in more extreme cases, etching, roughening and disintegration. This is the general type of effect produced on non-resistant enamels. The second is usually confined to resistant enamels, and is generally known as the "shadow" effect. It rarely involves any readily visible loss of gloss, but when a bright light is viewed by direct reflection at the enamel surface, a faint darkening of the surface can be seen where the acid has been in contact with it.

This "shadow" effect is sometimes produced on very resistant enamels by weak acids, and frequently stronger acids produce no greater and sometimes a lesser effect. It is essentially a property of the very outside surface of the enamel and not of the main body of the enamel layer. This indication of special properties of the surface of the enamel resembles that found with repeated extractions with hot acid, and described in the previous Report. It is conceivable that it may be related to the presence of certain substances as mill additions, as it rarely appears on dry-process enamels. That it is quite a separate effect from the usual form of acid attack was well shown by tests on two enamels. The one found by the previously recommended method to be the more resistant gave the more pronounced shadow effects, thus reversing the order of classification.

Considerable discussion took place regarding this "shadow" effect, and whether it should be regarded as evidence of failure to pass a spot test. It was finally concluded that it should not be a cause of rejection, but that due credit should be given to enamels which were free from the effect. It then remained to devise a means of testing the acid-treated surface which, while revealing any staining or etching, would not affect a "shadow." The method needed to be simple, rapid and decisive, and to use materials readily available. These conditions were considered to exclude any optical measurements, valuable as these would be for the purpose of research. From the consumers' point of view, a loss of gloss or smoothness is significant in that it provides a key for dirt particles, thus spoiling the appearance of white or light-coloured enamels, and degrading the colour of darker coloured ones. From this it appeared that the power of the surface to absorb a solid or liquid reagent might serve to identify a definite attack by the acid. In this connection the pencil-marking included in the Porcelain Enamel Institute Test was considered to be on the right lines, but it was felt that a distinction between degrees of marking, such as by the wet- and dry-rubbing tests, was not necessary, as any absorption of testing reagent would be regarded as a failure to withstand the particular solution, and need for repeating with a weaker testing solution.



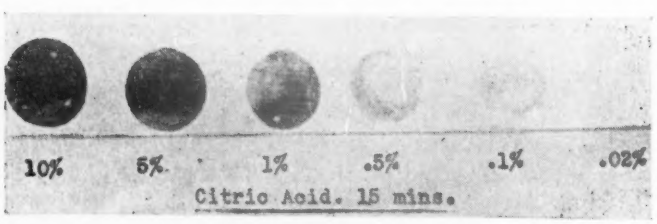
White Dry-Process Cast Iron Enamel (Used on Sanitary Ware).



White Wet-Process Cast Iron Enamel (Used on Sanitary Ware).

A B C D E F

Black Sheet-Iron Enamel (Used on Cookers).



White Dry-Process Cast Iron Enamel (Used on Sanitary Ware).

FIG. 3.—SPOT TESTS WITH COLD ACIDS. TIME OF CONTACT, 15 SECS. SOLUTIONS USED:—A, 1 PER CENT. HYDROCHLORIC ACID; B, 1 PER CENT. OXALIC ACID; C, 1 PER CENT. PHOSPHORIC ACID; D, 1 PER CENT. CITRIC ACID; E, 1 PER CENT. SUCCINIC ACID; F, 0.5 PER CENT. PHTHALIC ACID; AND G, 1 PER CENT. POTASSIUM HYDROGEN PHTHALATE. SEE ALSO TABLE II.

The experiments tried with liquids depended on the absorption of one solution, which when treated with another suitable solution, produces a characteristic appearance. Solutions found to work satisfactorily are lead acetate and potassium iodide, which give a yellow precipitate of lead iodide. If a few drops of lead acetate solution are placed on the treated part of the enamel for a few minutes and all excess then removed by wiping with a clean, damp cloth, then a drop of potassium iodide will produce a bright stain on any attacked part of the enamel. It is even possible in many cases to transfer the lead acetate to a filter paper soaked in acetic acid solution, even after the enamel surface has been thoroughly washed. On placing a drop of potassium iodide solution on the filter paper, a yellow stain will be produced if the enamel has been attacked, so that lead acetate has been absorbed. This latter method only works on enamels having a fair degree of acid-resistance. Using a similar procedure with ammonium sulphide instead of potassium iodide, a black stain is obtained. A dark stain so produced shows up very readily on a white or light coloured enamel, but on a black enamel, a white precipitate is not so prominent. In any case, acid attack on a black enamel involves a kind of "bleaching" action, the enamel surface becoming more or less grey in colour.

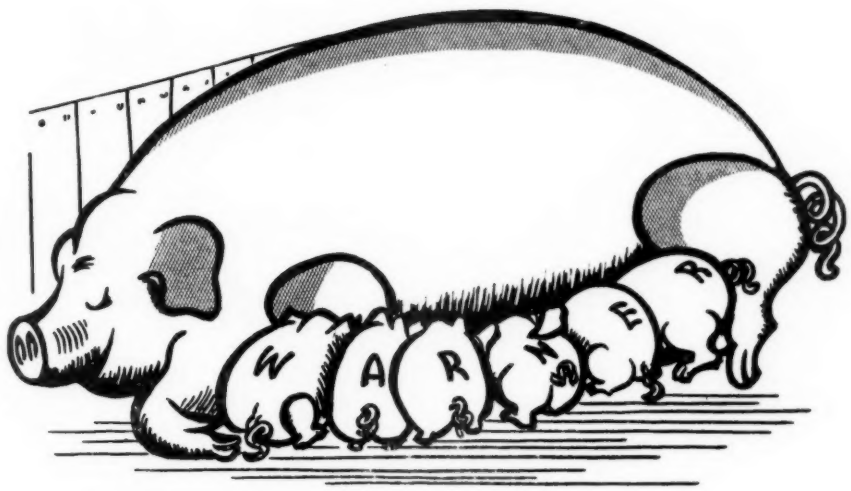
Turning to the use of solid substances for testing the absorbing power of the attacked enamel surface, one of the first tried was a colour oxide as used for the preparation of coloured enamels. The most successful of these was a selenium red which, having been prepared by a precipitation process, was finely divided and of a texture which seemed particularly suited to the purpose. Results almost as good were obtained with a precipitated black oxide. These two would thus be suitable for all white and light coloured enamels. For black and dark coloured enamels, a light or white colour is required to show up the attacked surface. Of a number of white substances tried, finely divided titanium oxide gave the best results. As yellow has been stated to be the most readily visible colour in combination with black (hence its use for road signs), a few yellow pigments were tried. Lead chromate proved satisfactory for the purpose, while cadmium sulphide also gave a readily visible stain. No doubt a yellow colour oxide, if prepared by precipitation, would answer equally well.

Fig. 3 shows photographs of stains produced on white enamel by various acid solutions after treatment with red and black colour oxides, and also stains produced on black enamel and shown up with titanium oxide. The enamels shown here are not really acid-resistant, but they show very well the types of stain produced by rubbing colour oxide into the treated part of the enamel surface. The acid solutions used are those with the graded *pH* values, as mentioned previously when discussing the testing solutions to be employed. As shown by Table II for different types of enamel, many enamels show no effect at all when tested with much stronger acid solutions than those shown here, which cover only a limited range.

The range of effects shown in these photographs is also rather limited, although sufficient to illustrate the type of result to be expected. It was hoped to be able to devise a photographic standard for use in comparing with actual results, but this did not prove to be practicable. In the first place, the intensity of colour produced is only proportional to the degree of attack up to a certain stage. When

(*Continued on page* 93.)

MIGHTIER YET . . .



Present day conditions call for an even larger range of Warner Pigs—in fact we wish we could litter our stock ground with them.

At any rate we are producing many analyses which, though they may not be so familiar to the Foundry Trade as our ordinary grades, are helping numerous firms to solve their war-time problems.

If we can help you, we help Britain to become "Mightier Yet" —that is our conception of war-time service.

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The Week's News in Brief

Trade Talk

THE CARBORUNDUM COMPANY, LIMITED, state that the telephone number of their new London office address is Ruislip 3586, and not 3568.

THE MINISTRY OF LABOUR, in conjunction with the Board of Education, is organising courses of lectures in foremanship at Technical Colleges in a considerable number of industrial areas.

ACCORDING to "Steel," the hull of the new Canadian-built 28-ton cruiser tank is a solid 10-ton piece of steel, welded to the tank frame. No rivets are employed. The turret also is solid cast steel.

AN ACCIDENT HOSPITAL and rehabilitation centre has been established in Birmingham. To keep in close contact with industry the appointment of an industrial liaison officer with experience of factory conditions is contemplated.

THE TRUSTEES of the late Mr. C. Peter Sandberg have arranged to carry on the business of Messrs. Sandberg, consulting and inspecting engineers, under the management of Mr. A. J. W. Graham, with the assistance of Mr. J. F. Sandberg.

UNITED KINGDOM firms who desire to apply to the Department of Overseas Trade for recommendation in support of applications for exit permits for commercial journeys abroad should in future communicate with the Department of Overseas Trade (Exit Permit Section), Millbank, London, S.W.1.

A MEETING of the London Local Section of the Institute of Metals will be held at the Junior Institution of Engineers (Incorporated), 39, Victoria Street, Westminster, S.W.1, on Thursday, September 4, at 6 p.m., when Dr. W. D. Jones, M.Eng., will deliver an address on "Developments in Powder Metallurgy."

UNDER A BOARD OF TRADE ORDER (S.R. & O. 1941 No. 1072), coming into force on August 14, licences will be required to export to all destinations certain additional manufactures of iron and steel, all kinds (including certain specified parts thereof) of mechanically-propelled road vehicles and further types of electrical measuring instruments.

THE FOLLOWING COMPANIES have been elected members of the British Cast Iron Research Association. The name of the representative is given between brackets:—Brockmoor Foundry Company, Limited, Brierley Hill (Mr. R. B. Bayliss); George Brown & Bros., Limited, Stockton-on-Tees (Mr. J. K. Green); Josiah Guest & Sons, West Bromwich (Mr. J. J. Lavender); Simplex Electric Company, Limited, Oldbury (Dr. J. W. Jenkin); James Laing, Son & Company (Manchester), Limited, Manchester (Mr. A. L. Okell); and F. & M. Supplies, Limited, London (Mr. G. Millard). Mr. K. C. Barraclough, B.Sc., A.I.C., and Mr. J. D. Hobson, both of Sheffield, have joined as Associate Members.

THE CONFERENCE of the National Union of Blastfurnacemen at Southport endorsed the arrangement made for the application of the Essential Work Order to the iron and steel industry. The general secretary, Mr. A. Callighan, of Middlesbrough, reported that complete agreement had been reached with the employers in relation to the stand-by wage in the Order and all matters relating thereto, so that when the Minister of Labour issued the Order, there could be no difficulty in its application to this important section of the iron and steel industry. The general secretary also reported on the agreement made with the Associated Ironmasters for the payment of women who will be drafted into the industry under war conditions.

A TANK BOARD has been appointed by Lord Beaverbrook, the Minister of Supply. Mr. Geoffrey Duke Burton is the chairman of the Board, and the other members are Mr. Oliver Lucas, in charge of design and development; Mr. George Usher, Director-General of Tank Supply; Major-General Macready, and Major-General Pope. Mr. Burton is managing director of the Birmingham Small Arms Company, Limited, chairman of William Jessop & Sons, Limited, and B.S.A. Tools, Limited, and a director of the Round Oak Steelworks, Limited, and the Earl of Dudley's Baggeridge Colliery, Limited. Mr. Oliver Lucas is deputy-chairman and joint managing director of Joseph Lucas, Limited. Mr. Usher is managing director of International Combustion, Limited, and chairman and joint managing director of Aberdare Cables, Limited.

THE PRINCIPAL ESSENTIAL WORK ORDER did not interfere directly with any power an employer might have to suspend a worker from his job, but the guaranteed minimum wage provisions had the effect of entitling a worker to wages in respect of the whole of the "prescribed period" (a week or a day) even though he might have been suspended for part of it on disciplinary grounds. In practice, therefore, the employer was stopped by the Order from utilising suspension without pay as a disciplinary measure where workers committed offences which, though serious, were not serious enough to justify dismissal. The effect of this was to leave no choice but dismissal in many cases where a short suspension would have met the needs, and also was likely to encourage the infliction of fines, which is generally agreed to be an unsatisfactory system. It has been decided to restore the right to suspend without pay up to a limit of three days. Accordingly, under the Essential Work (General Provisions) (Amending) Order, 1941, a new provision is now added to the principal Order to the effect that, where an employer suspends a worker in accordance with his conditions of service for a period not exceeding three days, the worker will not be entitled to the guaranteed wage for the days in which he is suspended unless: (1) He appeals to the Local Appeal Board within three days of the beginning of the suspension, and (2) either the Board is unanimously of the opinion that the suspension was justified, or, if the Board is not unanimous, the National Service Officer is of the opinion that the suspension was unjustified.

Personal

MR. WILLIAM SINGLETON has been elected technical director of British Lead Mills, Limited.

MR. ALEXANDER STORRAR has been appointed a director of Henry Robb, Limited, the Leith shipbuilders.

MR. EDGAR N. HILEY has been appointed secretary of the Brassfounders' Employers' Association, Birmingham.

MR. LAWRENCE A. BRATT, chairman and managing director of Bratt Colbran, Limited, has been appointed a director of Radiation, Limited.

MR. W. H. BOWLEY has been elected a director of Ambrose Shardlow & Company, Limited, Sheffield. He has been with the firm for 35 years, being appointed secretary in March, 1938.

MR. ANDREW BUTLER, of Cleator Moor, who for eight years has been on the Council of the Cumberland Iron Ore Miners' Association, has been elected chairman for the next twelve months.

MR. HENRY BLACKBURN (managing director) has been appointed chairman of Thomas Blackburn & Sons, Limited, structural engineers and steel rerollers, of Preston, in place of Mr. Russell Edwards, who retains his seat on the board.

MR. SUMMERS HUNTER, managing director of the North-Eastern Marine Engineering Company, Limited, and Mr. Andrew Sprott, secretary of the Wallsend Slipway & Engineering Company, Limited, have been appointed magistrates for Wallsend.

PROF. W. N. THOMAS, Professor of Engineering at the University of Wales, is among technical officers who have been placed at the disposal of the Russian Government by the Ministry of Supply. Prof. Thomas is attached to the Department of Research and Experiment of the Ministry.

FLYING OFFICER F. WILLIAM FISHER SCOTT RUSSELL, 25-year-old son of Mr. and Mrs. Frank S. Russell, is reported missing. He joined the R.A.F. before war was declared. His father was chairman of General Refractories, Limited, a position from which he resigned in January, 1939.

Wills

RICHMOND, ROBERT, partner in John Richmond & Company, metal merchants, Glasgow	£8,292
SHAW, THOMAS, of H. Shaw & Son, magnet manufacturers, Sheffield	£80,082
TURTON, FRANK, Worthing, Sussex, formerly of Sheffield, steel manufacturer	£5,477
BROWN, F. E., of Holmfirth, Huddersfield, chairman of David Brown & Sons (Huddersfield), Limited	£63,456
SMITH, SIR ALLAN MACGREGOR, former chairman of the management board of the Engineering and Allied Employers' National Federation...	£38,704

Parliamentary

Scrap Metal Stocks

MR. STOKES asked the Parliamentary Secretary to the Ministry of Supply whether he could give any estimate of the stocks of non-ferrous scrap metal in this country, and what steps he proposed to take to reduce them to normal.

MR. HAROLD MACMILLAN replied that, according to returns made by 220 merchants and 30 ingot makers, the stocks of copper, brass and other copper alloy scrap amounted to some 24,000 tons on May 31, 1941. These stocks were not unduly large in view of the present scale of manufacturing industry. The Ministry of Supply encouraged the use of a proportion of scrap metal wherever practicable, and had undertaken to buy low-grade ingots of copper and brass which could be made from the inferior grades of scrap.

Scrap Salvage from Bombed Sites

CAPT. LYONS asked the Home Secretary whether he would indicate the policy that was being pursued in relation to the disposal of the potential scrap metals still lying untouched, uncut or unsorted in damaged areas; and whether, after due consideration of charges involved and availability of labour and transport, he would issue guidance by circular to the local authorities and others concerned.

MISS WILKINSON, who replied, said that there was continued need for iron and steel scrap and further arrangements had been made to ensure that full use was made of materials which could be recovered from buildings damaged by air raids. Where the recovery of iron and steel by local authorities was incidental to the work of clearance or demolition of damaged sites, the material would be made immediately available to the Iron and Steel Control of the Ministry of Supply. Also, the Ministry of Works and Buildings would act on behalf of the Ministry of Supply in arranging for the salvage of iron and steel from damaged sites which would not otherwise be cleared, and the Ministry of Supply would be responsible for disposal. The Minister of Works and Buildings had already made a preliminary survey of the scrap steel likely to be made available in this way, and a weekly programme of recovery would be arranged. Special arrangements had been made in the London Region.

Munitions Production

MR. MACMILLAN, Parliamentary Secretary to the Ministry of Supply, replying to a debate on the supply position, said that the first quarter of this year showed an increase in the production of both guns and tanks of more than 50 per cent. over the last quarter of 1940; and the second quarter of 1941 showed an increase of more than 100 per cent. over the last quarter of 1940. A great deal had been done to secure economy in the use of raw materials and to deal with the difficult and rather intractable problem of salvage. The local authorities were doing their best to bring this service up to 100 per cent. efficiency. So far as scrap was concerned, it was of vital importance that we should not only continue to import scrap, but also fully to develop our home resources in order to provide a strategic reserve for the production of steel. The machine-tool industry, which even before the war had been raised to more than its normal tempo, had since been greatly expanded, with the result that to-day our production of machine tools was six times that of the normal peacetime output. At the same time, provision had been made for the making of enormous quantities of jigs, gauges and small tools by firms who specialised in this kind of equipment. Exaggerated statements of wilful absenteeism on the one hand and managerial inefficiency on the other could only do harm.

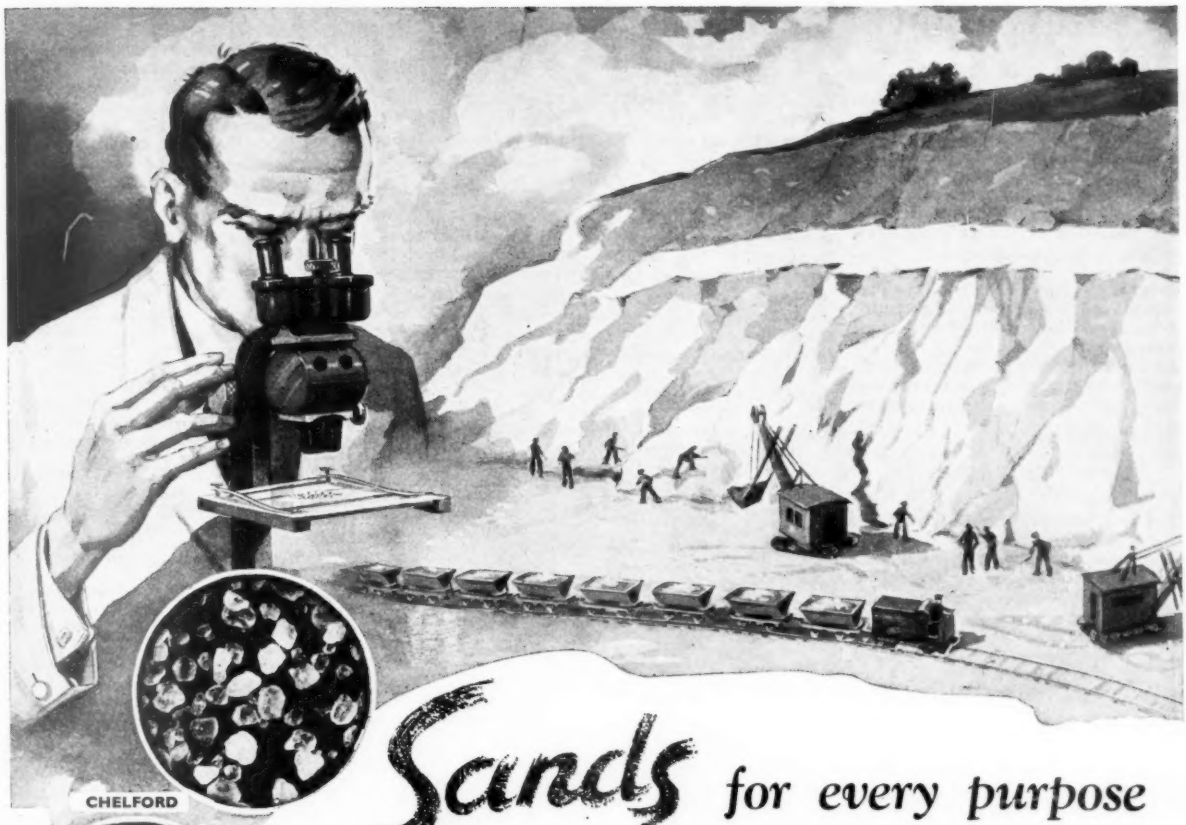
Obituary

MR. HAROLD DALBY, a director of the Girdex Engineering Company, Limited, Tyseley, died at Birmingham on July 24, aged 45.

THE DEATH has occurred suddenly of Mr. Alex M'Dougall, works superintendent, of the National Steel Foundry, Kirkland, Leven.

MR. PHILLIP ARTHUR NORTON, of the Norton-Harty Engineering Company, Great Bridge, Staffs, died on July 29, in his 71st year.

THE DEATH has occurred at Rosedene, Carmunnock Road, Busby, on July 26, of Mr. Archibald M'Neil, J.P., of the Kinning Park Ironworks, Glasgow.



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Raw Material Markets

At this time of the year many iron and steel consuming works are idle for about seven days in order to give a much-needed break to their employees and to facilitate repair work; consequently, there has been rather less activity in market circles of late, but this does not necessarily indicate any slackening off in the volume of orders on hand. A certain amount of lost time due to overhauls to plant is inevitable at the best regulated establishments, while it has been proved time and again that output suffers if the workers are not given an annual holiday; in view of the considerable overtime which employees have been called upon to do in past months, it is all the more necessary for a break to be taken before they are required to face another strenuous winter of working in black-out and other conditions arising out of the war which tax the workers to a greater degree than usual.

Pig-Iron

MIDDLESBROUGH—Foundry iron is moving into consumption steadily in this district and extra tonnages are being taken up in order to counteract the shortage of hematite. Thus, large orders are being placed with the Midlands furnaces, which are now supplying consumers on the North-East Coast because of the preoccupation of Cleveland ironmakers with the manufacture of basic iron and other qualities needed more especially by the steelworks. Fortunately, Derbyshire and Northamptonshire producers are able to cater adequately for the requirements of users here and are, in fact, delivering supplies over and above those needed for immediate use, so that useful stocks are being accumulated at many points.

While the situation with regard to hematite supplies has improved, it is still necessary to exercise the utmost economy in the use of this type of iron. Production has recently been expanded and scrap and refined iron have been incorporated in furnace mixtures more freely, thus releasing a considerable tonnage of hematite, which is being reserved for the most important contracts. High-priority consumers are getting deliveries through with less delay than was experienced a month or two ago and further improvement is hoped for in the near future.

LANCASHIRE—The quietness in the light-castings trade and among many jobbing foundries is not due to seasonal conditions, but to the restrictions placed on their business by wartime conditions, which have had widespread repercussions both in home and export trade. There has, perhaps, been some slight change for the better as compared with a few months ago, but there is little reason to suppose that these foundries will become fully occupied again until after the cessation of hostilities, when the building industry may be expected to make heavy demands upon the resources of the makers of light castings. Textile-machinery makers, too, are far from active and are in need of greatly reduced quantities of iron. Present conditions in the heavy engineering industry are the reverse of those prevailing in the light-castings trade, and demand for foundry iron from Derbyshire and Staffordshire producers is maintained at a substantial level. Heavy electrical engineers and machine-tool makers are particularly well placed for orders, the needs of Government departments making considerable inroads into their outputs.

MIDLANDS—Production of low-phosphorus and hematite irons is fully accounted for by the requirements of the heavy engineering industry, while high-phosphorus iron is also being taken up in increasing tonnages, a large amount of the latter being needed to eke out supplies of the better quality irons. Heavy castings continue to be called for on a large scale by Government departments in furtherance of the war effort and it may be definitely accepted that priority demands will continue to absorb full outputs. In addition to high-phosphorus iron, refined iron and steel scrap are being utilised by many ironfounders in order to make up for the absence of sufficient supplies of other grades. No better conditions are reported from the light-castings trade, which has been on short time for months past owing to the lack of support from the building trade and the difficulty in procuring licences for export. Many of these foundries have fairly large stocks of high-phosphorus iron.

SCOTLAND—Very strong and active conditions exist in the Scottish heavy engineering industry following the break for holidays and repairs, and order-books are filled to capacity. Demand for pig-iron is at a substantial level and deliveries are at times on the slow side, although essential users' requirements are satisfied promptly in most instances. Adequate tonnages of basic iron are reaching the steelworks, but more hematite is needed. The light-castings industry is still employed at much under capacity and only a few establishments are able to report full-time working. Iron for this trade is being obtained in the Midlands of England, as the supply of Cleveland iron remains cut off, makers in the North of England concentrating on the production of iron for steelmaking purposes.

Coke

Supplies of foundry coke continue to be delivered under contract according to schedule, and many consumers are in possession of considerable reserve stocks. The recent increase in the price of Welsh coke has not impaired the steady trend of business in fuel from that area. For delivery to Birmingham and Black Country stations, the current price of Durham best foundry coke remains at 62s. 9d. per ton, but a revision of this quotation is expected shortly.

Steel

While larger tonnages of special steels are being called for, demand for certain other qualities tends to diminish to some extent. For example, carbon steel is rather less active, while joists, sections and sheets are not being taken up so freely as they were, as constructional work involving the use of these products is reduced for the time being. The authorities have deemed it prudent to draw on existing stocks of late, but it is not expected that this procedure will be carried on for very long, as it is recognised that it is in the national interest to maintain stocks at a reasonable level. In view of holiday interruptions and lost time due to repairs and overhauls it is likely that output of steel this month will be lower than for many months past; at the same time, it is appreciated that workers, who have for so long been operating without a break, should be given a rest, while plant renovations also are desirable if works are to continue at concert pitch.

Scrap

The scrap position is undoubtedly much easier than it was a short time ago, due not only to freer supplies, but also to a certain falling away in consumption. Holidays, of course, are largely responsible for this. Merchants have not the slightest difficulty in disposing of scrap suitable for the steel furnaces and bulk tonnages are being bought by steelmakers. Scrap for the foundries is coming forward more regularly and foundrymen, generally speaking, are not inconvenienced in any way in this respect.

Metals

COPPER—There is no new feature to report in connection with the copper market; supplies for essential users continue to come through satisfactorily, but other consumers, generally speaking, are still excluded from the scheme for allocating available supplies. Consumption is maintained at a heavy tonnage, with the trend in an upward direction with the coming into operation of additional working-up factories on Government account. In the United States, copper has now been placed under full priorities.

TIN—Prices of tin on the London Metal Exchange suffered a relapse prior to the break for the holiday. Apart from selling by smelters' agents there has been little of note to record, the market being thinly supported by consumers. It is generally felt that the serious political situation in the Far East is not affecting the market so much as might have been expected. Malayan producers, it is understood, are contemplating rescinding all open forward contracts with Japan. The owners of the East Pool and Agar mine in Cornwall have announced that they are being forced to close down mining operations owing to an inadequate supply of labour. Financial assistance has been granted by the authorities, but the latter have not been able to allocate the labour required to work the mine economically. It is expected that the ore lying broken in the stopes will be disposed of for treatment and that operations will thus continue for a few months more. The question of controlled prices for tin in the United States is still rife in America and, according to intimations which have reached London recently, the U.S. Government view with disapproval the prevailing high price of the metal. It is reported that the Government have requested buyers to refrain from making fresh purchases until stocks have been lowered to the level obtaining about twelve months ago.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £256 15s. to £257; Friday, £256 5s. to £256 15s.; Tuesday, £256 10s. to £256 15s.; Wednesday, £256 15s. to £257.

Three Months—Thursday, £259 15s. to £260; Friday, £259 15s. to £260; Tuesday, £259 15s. to £260 5s.; Wednesday, £259 15s. to £260 5s.

SPELTER—The bulk of the spelter consumed in the United Kingdom is taken up by works engaged on Government and other important contracts, particularly brass mills and galvanisers. Supplies for urgent orders are sufficient, but there is little metal to spare for other purposes. In the United States, home defence contracts and orders for the British war effort are absorbing large quantities of zinc.

LEAD—The lead supply position remains the easiest of all non-ferrous metals, but the Control authorities are maintaining a watchful eye on the situation and are regulating distribution carefully, although a certain tonnage is being handed out to consumers engaged on ordinary domestic work. Cable and battery manufacturers are busily employed and are using substantial supplies of lead. The Government of Burma has announced the freezing of Japanese assets in Burma, with effect from July 26. This measure will prevent all future trade except that specifically licensed. One of Burma's chief exports to Japan is lead, of which an amount valued at slightly under £400,000 goes annually to Japan. Exports of lead to Japan have been at a reduced level for some time past owing to absence of supplies for export.

Reports and Dividends

Rippingilles—Dividend of 6% (7½%).

E.N.V. Engineering—Interim dividend of 7½% (same).

Josiah Parkes & Sons—Interim dividend of 4% (same).

Warner & Company—Dividend of 5% (nil) on the ordinary shares.

Ward & Goldstone—Final dividend of 10%, making 20% (same).

Blythe Colour Works—No interim dividend on the ordinary shares (same).

Richardsons Westgarth—Dividend of 7½% for the year to March 31 (same).

John Bolding & Sons—Interim dividend on the ordinary shares of 4% (same).

Belfast Ropework—Final dividend of 4% on the ordinary shares, making 7% (same).

Aveling-Barford—Final dividend of 5% (7½%), making 10%, free of tax (12½% net).

Henry Hope & Sons—Net profit to March 29, £39,327 (£68,067); forward, after preference dividend, £25,577.

Anglo-Greek Magnesite—Profit for 1940, £21,241; brought in, £6,860; final dividend of 5% on the ordinary shares, making 8%; carried forward, £14,101.

Yorkshire Copper Works—Net profit for 1940, £90,592 (£135,290); dividend of 10% on the ordinary shares (same); to general reserve, £50,000; forward, after preference dividends, £15,945 (£16,528).

Fawcett Preston & Company—Net profit to March 31, after taxation, etc., £7,099 (£12,681); dividends on the 6% preference shares, on the 5% funding certificates, and of 15% (same) on the ordinary shares; forward, £10,459 (£5,387 after £8,000 to reserve).